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SURGERY

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SURGERY

VOL. 38 AUGUST, 1955 NO. 2

Original Communications

THE RELATION BETWEEN SIDEROPENIA AND ANEMIA AND THE OCCURRENCE OF POSTCIBAL SYMPTOMS FOLLOWING PARTIAL GASTRECTOMY FOR PEPTIC ULCER

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THE occurrence of postcibal symptoms, such as fatigue, pallor, nausea, palpitation of the heart, epigastric pain, and sometimes diarrhea as well, a short time after meals following partial gastrectomy has attracted increasing attention during recent years, inasmuch as these symptoms have proved in certain cases to be sufficiently severe to endanger the good results of the operative management of the peptic ulcer. "Postcibal symptoms" (post cibum = after meals, after food intake) is the term applied to these symptoms by Meurling (1953), among others, in his study on these phenomena, and would seem, on the whole, to cover other designations for the same symptoms such as postprandial or postcoenal symptoms, and the dumping syndrome.

The frequency with which the postcibal symptoms occur after partial gastrectomy will be found to be comparatively high. Muir (1949) and Goligher and Riley (1952) reported an extremely high incidence, 73 per cent with symptoms, while Meurling (1953) observed that 41 per cent in his investigation had definite symptoms. Wallensten (1954) found 25.5 per cent with symptoms in his material. It should be noted, however, that a large part of his material was made up of patients with partial gastrectomy performed according to Billroth I. Wallensten also observed in his investigation that Billroth I intervention was followed by severe postcibal symptoms appreciably less frequently than Billroth II partial gastrectomy. This phenomenon was pointed out earlier by Perman (1947) and Bohmansson (1950), among others. The difference appears to be particularly evident in female patients.

In all probability, there is no single cause of the occurrence of these postcibal symptoms, and a number of factors have been suggested in the earlier

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literature which might conceivably contribute to their origin. From the comprehensive review of the literature on this subject in Meurling's study published in 1953, it is evident that there are principally three different views on the point of origin of these symptoms: (1) they might originate in the small intestine for instance, dumping stomach, jejunal distention, irritation of the small intestine and increased motility therein, hyperemia in the vicinity of the splanchnic nerves, jejunitis, allergy, reflux into the afferent intestinal loop, stasis in the afferent loop, and so on; (2) they might originate in the gastric remnant, for instance, distention of the gastric remnant, gastritis, achylia, traction on the gastric remnant, and so forth; and (3) the origin might be found elsewhere. Hypoglycemia, reduced serum potassium, and even anemia have been among the suggested causes.

After a critical evaluation of all these causes, it may be said that it is conceivable that a number of factors contribute to the origin of postcibal symptoms following partial gastrectomy. Meurling expressed the opinion that the cause is probably usually the response of the small intestine to a sufficiently intense, nonspecific irritation.

The possibility that anemia or sideropenia might contribute to the origin of postcibal symptoms, as suggested earlier by other writers (Bruusgaard, 1946; Fehr and Ott, 1950; Lyngar, 1950; Jasinski and Ott, 1951; Drablös, Lindén, and Skjelbred, 1951), is interesting, and has been investigated in detail by Wallensten (1954). Through earlier investigations (Heilmeyer and Plötner, 1937; Waldenström, 1944) we know that sideropenia is accompanied by certain epithelial changes in the nails, buccal mucosa, and so on. If the occurrence of the postcibal symptoms may be regarded as the response of the intestinal mucosa to a nonspecific irritation, there is reason to assume that the intensity of the irritation is not the only determining factor; the sensitivity of the mucosa may also play a significant role in the origin of the symptoms. It might also be conceivable that in sideropenia epithelial changes occur in the intestinal mucosa also, and that it may be assumed to be more sensitive to nonspecific irritations than is usual. Accordingly, we might expect to find a higher incidence of postcibal symptoms in patients with sideropenia than in those with normal hemoglobin and serum iron values. In an earlier study published by the author in 1954, it was demonstrated that such is the case. The present investigation, based on more extensive material of examined patients, is presented in an attempt to clarify further the question of a relation between the iron balance and the occurrence of postcibal symptoms.

STATISTICAL METHODS

In comparing two or more proportions the χ^2 method was employed (see R. A. Fisher, *Statistical Methods for Research Workers,* ed. 10, Edinburgh, 1946, Oliver & Boyd Limited, pp. 85-88).

In studying the influence of a certain factor in several comparable groups of data, a combined test of significance was obtained by adding the individual χ^2 values and their corresponding degrees of freedom (d.f.).

The following notations are employed throughout the paper:

Significance level $P < 0.05$ almost significant*
$P < 0.01$ significant**
$P < 0.001$ highly significant***

THE PRESENT INVESTIGATION

The material comprises a series of 587 patients who underwent partial gastrectomy for peptic ulcer during the period between 1932 and the end of 1949. In 439 cases the patients were submitted to the Billroth II (B II) type of partial gastrectomy, in 148 to the Billroth I (B I) type. The material includes 425 men (104 B I and 321 B II) and 162 women (44 B I and 118 B II).

The B I partial gastrectomies were performed during the aforementioned period in the Surgical Department of Falu lasarett, where this form of resection was the standard procedure in operative management of peptic ulcer. The B II partial gastrectomies were all performed in the Surgical Department of Serafimerlasarettet, where this was the standard resection method during the corresponding period.

The patients, with few exceptions, were all personally controlled by me in follow-up examination at the respective hospitals. In these follow-up examinations an extremely thorough system of questioning, with the use of so-called "leading questions," was followed in establishing the postoperative symptoms. In the gradation of the postoperative postcibal symptoms, the same basis of evaluation and the same system of designation as those used by Meurling (1953) were employed. Accordingly, the following scheme was used in gradation of the postcibal symptoms:

Grade Pc 0 = No postcibal symptoms

Grade (Pc) = Occasional, slight, or latent postcibal symptoms. By "latent postcibal symptoms" are meant those cases where the patients earlier had symptoms, but where suitable dietary and other precautions had resulted in freedom from symptoms

Grade Pc = Definite postcibal symptoms

- Pc 1 = Mild postcibal symptoms
- Pc 2 = Moderate postcibal symptoms
- Pc 3 = Severe postcibal symptoms

Blood studies with determination of the serum iron content, the hemoglobin content, and the erythrocyte count were carried out on all patients. The serum iron determinations were performed according to Agner's method. The hemoglobin content was determined in the B II series with a photoelectric colorimeter after dilution of the blood with 0.04 per cent ammonium hydroxide solution, and in the B I series with an Autenrieth colorimeter. The latter method was standardized with that used in the B II series. The serum iron

content was obtained in micrograms per 100 ml. of blood (γ per cent), and the hemoglobin in grams per 100 ml. of blood (Gm. per cent); 100 per cent corresponds to 16 Gm. per cent.

The lower normal limit for serum iron content lies at 60 to 70 γ per cent (Waldenström, 1946; Tötterman, 1949). According to Andersson (1953) it is probable that sideropenia exists when the serum iron content falls below 90 γ per cent. With this in mind the material reported here was classified in the three following groups:

Definite sideropenia with serum iron, below 60 γ per cent;
Suspected sideropenia with serum iron, 60 to 89 γ per cent;
Definitely normal with serum iron, ≧ 90 γ per cent.

There seems to be no great divergence between different investigations with respect to the normal level for the hemoglobin content. Vahlquist (1948) placed the normal values at 15.4 Gm. per cent for men and 13.6 Gm. per cent for women. These values were obtained by collocation of data from earlier, principally Scandinavian, studies. Bierring (1940) gave 15.6 Gm. per cent for men and 13.6 Gm. per cent for women as the mean hemoglobin content, with limits of variation of ± 2 Gm. per cent. His figures were based on his own studies and on a collocation of earlier reported data taken from investigations throughout the world. Wintrobe (1951) placed the mean values at 16 Gm. per cent for men and 14 Gm. per cent for women, with ± 2 Gm. per cent as limits of variation. Vahlquist (1948) placed the lower normal limit at 13.6 Gm. per cent for men, 11.5 Gm. per cent for women. In accordance with the foregoing data, the material was divided with respect to hemoglobin content into the following groups:

Men	*Hgb in Gm %*	*Women*	*Hgb in Gm. %*
Normal	≧13.6	Normal	≧11.5
Slight anemia	13.5-11.5	Slight anemia	11.4-9.8
Pronounced anemia	11.4-9.8	Pronounced anemia	9.7-8.1
Grave anemia	9.7	Grave anemia	≦8

The distribution of the material with respect to the occurrence of different grades of postcibal symptoms according to the classification given earlier is shown in Table I.

TABLE I. DISTRIBUTION OF POSTCIBAL SYMPTOMS IN 587 OPERATED CASES OF GASTRO-DUODENAL ULCER COLLOCATED ACCORDING TO OPERATIVE METHOD

GRADE OF POSTCIBAL SYMPTOMS	B I		B II		B I + II	
	NO. CASES	PER CENT	NO. CASES	PER CENT	NO. CASES	PER CENT
Pc 0	76	51.4	193	44.0	269	45.8
(Pc)	40	27.0	96	21.9	136	23.2
Pc 1	23	15.5	89	20.3	112	19.1
Pc 2-3	9	6.1	61	13.9	70	11.9
Total	148	100.0	439	100.0	587	100.0

It is evident from the table that when a thoroughly effective questioning technique is employed, a large percentage of the patients operated on

have some form of postcibal symptoms. It becomes apparent at the same time that in the B I operated cases postcibal symptoms were reported less extensively than in the B II cases. Statistical analysis gives $\chi^2 = 9.6^*$, with d.f. = 3. If the distribution of the definite postcibal symptoms is examined, it will be seen that these occur considerably less frequently in the B I operated series than in the B II. The incidence was 21.6 per cent in the B I series and 34.2 per cent of the B II. The 12.6 per cent difference in the incidence is statistically significant, $\chi^2 = 87.3^{***}$, with d.f. = 1.

TABLE II

GRADE OF POSTCIBAL SYMPTOMS	MEN				WOMEN			
	B I		B II		B I		B II	
	NO. CASES	PER CENT	NO. CASES	PER CENT	NO. CASES	PER CENT	NO. CASES	PER CENT
Pc 0	60	57.7	154	48.0	16	36.4	39	33.1
(Pc)	22	21.2	74	23.0	18	40.9	22	18.6
Pc 1	16	15.4	61	19.0	7	15.9	28	23.7
Pc 2-3	6	5.7	32	10.0	3	6.8	29	24.6
Total	104	100.0	321	100.0	44	100.0	118	100.0

In Table II the material is classified according to sex as well. It is evident that postcibal symptoms occurred to an appreciably greater extent in women than in men. The differences are statistically significant, $\chi^2 = 19.4^{**}$, with d.f. = 3.

TABLE III. POSTCIBAL SYMPTOMS AND SERUM IRON IN GAMMA PER CENT IN A SERIES OF 439 PATIENTS (321 MEN AND 118 WOMEN) OPERATED ACCORDING TO THE BILLROTH II METHOD

GRADE OF POSTCIBAL SYMPTOMS	SERUM IRON IN γ PER CENT					
	<60 γ PER CENT		60 TO 89 γ PER CENT		≧ 90 γ PER CENT	
	♂	♀	♂	♀	♂	♀
Pc 0	24 (41.4%)	12 (25.5%)	34 (47.9%)	10 (34.5%)	96 (50.0%)	17 (40.5%)
(Pc)	13 (22.4%)	6 (66.7%)	11 (15.5%)	6 (20.7%)	50 (26.0%)	10 (23.8%)
Pc 1	14 (24.1%)	12 (25.5%)	17 (23.9%)	9 (31.0%)	30 (15.6%)	7 (16.7%)
Pc 2-3	7 (12.1%)	17 (36.2%)	9 (12.7%)	4 (13.8%)	16 (6.4%)	8 (19.0%)
Total	58 (100%)	47 (100%)	71 (100%)	29 (100%)	192 (100%)	42 (100%)

It may be seen that sex and operative method determine, to a certain extent, the occurrence and distributional incidence of postcibal symptoms. In Tables III and IV the material is collocated with this taken into consideration and with respect to the serum iron content. The material is thus divided

TABLE IV. POSTCIBAL SYMPTOMS AND SERUM IRON IN GAMMA PER CENT IN A SERIES OF 148 PATIENTS (104 MEN AND 44 WOMEN) OPERATED ACCORDING TO THE BILLROTH I METHOD

GRADE OF POSTCIBAL SYMPTOMS	SERUM IRON IN γ PER CENT					
	<60 γ PER CENT		60 TO 89 γ PER CENT		≧90 γ PER CENT	
	♂	♀	♂	♀	♂	♀
Pc 0	11 (55%)	7 (36.8%)	8 (47.1%)	3 (33.5%)	41 (61.2%)	6 (37.5%)
(Pc)	4 (20%)	10 (52.6%)	4 (23.5%)	3 (33.5%)	14 (20.9%)	5 (31.0%)
Pc 1	2 (10%)	1 (5.3%)	3 (17.6%)	2 (22.2%)	11 (16.4%)	4 (25.0%)
Pc 2-3	3 (15%)	1 (5.3%)	2 (11.8%)	1 (11.2%)	1 (1.5%)	1 (6.2%)
Total	20 (100%)	19 (100%)	17 (100%)	9 (100%)	67 (100%)	16 (100%)

into three groups: one with serum iron content under 60 γ per cent, a second with values between 60 and 89 γ per cent, and a third with values ≧ 90 γ per cent.

It now becomes evident that there was a prevailing tendency throughout both B I and B II series and in both men and women toward more extensive occurrence of postcibal symptoms in the patients with low serum iron values. In a statistical analysis of the B II material, comparing the groups with serum iron of ≦ 60 γ per cent and those with serum iron of ≧ 90 γ per cent, we get $\chi^2 = 16.3^{**}$, with d.f. = 3, which is a significant value. In the B I series, where the tendency was the same, the material was too limited to permit statistical treatment.

TABLE V. DISTRIBUTION OF DIFFERENT GRADES OF POSTCIBAL SYMPTOMS IN RELATION TO THE HEMOGLOBIN IN GRAMS PER CENT AND THE SERUM IRON IN GAMMA PER CENT IN 408 MEN AFTER OPERATION FOR GASTRODUODENAL ULCER

GRADE OF POSTCIBAL SYMPTOMS	Hgb ≧ 11.5 gm. % Se Fe ≧ 90 γ %		Hgb ≧ 11.5 gm. % Se Fe < 90 γ %		Hgb < 11.5 gm % Se Fe < 90 γ %	
	NO. CASES	PER CENT	NO. CASES	PER CENT	NO. CASES	PER CENT
Pe 0	130	53.5	58	48.5	18	40.0
(Pe)	58	23.9	21	17.5	11	24.4
Pe 1	38	15.6	26	21.7	10	22.2
Pe 2-3	17	7.0	15	12.5	6	13.3
Total	243	100.0	120	100.0	45	100.0

In order to illustrate the effect of the severity of the anemia on the occurrence of postcibal symptoms, the material was divided into three groups: patients with normal or slightly reduced hemoglobin content (≧ 11.5 Gm. per cent Hgb in men and ≧ 9.8 Gm. per cent Hgb in women) and serum iron ≧ 90 γ per cent, patients with the same hemoglobin levels but with serum iron < 90 γ per cent, and patients with definitely lowered hemoglobin values (< 11.5 Gm. per cent in men and < 9.8 Gm. per cent in women) and with serum iron < 90 γ per cent.

TABLE VI. DISTRIBUTION OF DIFFERENT GRADES OF POSTCIBAL SYMPTOMS IN RELATION TO THE HEMOGLOBIN IN GRAM PER CENT AND THE SERUM IRON IN GAMMA PER CENT IN 162 WOMEN AFTER OPERATION FOR GASTRODUODENAL ULCER

GRADE OF POSTCIBAL SYMPTOMS	Hgb ≧ 9.8 gm. % Se Fe ≧ 90 γ %		Hgb ≧ 9.8 gm. % Se Fe < 90 γ %		Hgb < 9.8 gm. % Se Fe < 90 γ %	
	NO. CASES	PER CENT	NO. CASES	PER CENT	NO. CASES	PER CENT
Pe 0	22	38.6	30	36.1	3	13.7
(Pe)	15	26.3	20	24.1	5	22.7
Pe 1	11	19.3	17	20.5	7	31.8
Pe 2-3	9	15.8	16	19.5	7	31.8
Total	57	100.0	83	100.0	22	100.0

It may be seen that patients with definite anemia and sideropenia had an appreciably more extensive occurrence of postcibal symptoms than those with normal or slightly reduced hemoglobin content. It is also evident that a rising incidence of postcibal symptoms paralleled the degree of iron deficiency.

Since, as evidenced by the foregoing figures, there is reason to believe that a relationship exists between the occurrence of postcibal symptoms after partial gastrectomy and, the iron deficiency frequently following the same operation, I also tested the effect of iron therapy on the postcibal symptoms occurring in a limited number of patients. Intravenous iron therapy was used since it was found that patients with hypochromic anemia were frequently unaffected by orally administered iron, due to defective absorption or difficulty in tolerating it. Additional advantages of the intravenous administration are the more rapid therapeutic effect and more exact dosage. The preparation used was Ferrigen (Astra), developed by Agner. It consists of an easily soluble high-molecular carbohydrate to which the iron is bound. This preparation, which was experimentally and clinically tested

TABLE VII. EFFECT OF INTRAVENOUSLY ADMINISTERED IRON IN TWENTY-ONE CASES OF POSTCIBAL SYMPTOMS FOLLOWING B II PARTIAL GASTRECTOMY, SHOWING THE GRADE OF POSTCIBAL SYMPTOMS AND THE BLOOD VALUES BEFORE AND AFTER TREATMENT

		BEFORE IRON ADMINISTRATION					AFTER IRON ADMINISTRATION			
			BLOOD VALUES					BLOOD VALUES		
CASE NO.	SEX	GRADE OF POSTCIBAL	Hgb (GM. %)	RED BLOOD COUNT	SERUM IRON (γ%)	TOTAL i. v. IRON DOSE IN MG.	GRADE OF POSTCIBAL SYMPTOMS	Hgb (GM. %)	RED BLOOD COUNT	SERUM IRON (γ%)
1	♀	Pc 3	11.5	3.6	52	1,000	Pc 0	11.3	5.2	175
2	♀	Pc 1	8.0	3.8	14	2,800	Pc 0	11.4	4.2	63
3	♀	Pc 2	9.7	3.3	54	1,500	Pc 0	11.0	3.7	114
4	♀	Pc 2	10.9	3.5	59	1,000	Pc 0	12.7	4.2	86
6	♀	Pc 1	10.9	4.0	44	1,800	Pc 0			
7	♀	Pc 3			36	1,200	Pc 1	12.3	3.9	158
8	♀	Pc 1	11.3		44	600	Pc 0	11.5	3.6	88
11	♂	Pc 2	11.9	4.1	46	1,000	Pc 0	14.4	4.5	114
12	♀	Pc 3	7.0	3.5	10	1,500	Pc 1	11.5	3.9	85
13	♂	Pc 1	12.8	4.0	27	1,000	Pc 0	13.8	4.5	149
14	♀	Pc 1	12.3	4.5	34	1,000	Pc 0	12.5	4.3	83
16	♀	Pc 2	11.4	4.2	66	1,200	Pc 0	11.6	4.0	122
17	♀	Pc 2	10.9	4.2	31					
18	♂	Pc 1	13.1	4.3	82	1,000	Pc 0	12.8	4.3	95
20	♀	Pc 1	11.2	4.4	89	1,200	Pc 0	11.5	3.6	156
21	♂	Pc 2	10.3	3.2	38	1,400	(Pc)	12.1	4.5	101
22	♂	Pc 3	11.5	3.8	22	1,000	Pc 0			
25	♂	Pc 3	11.3	4.0	19	1,200	Pc 3	13.5	4.3	180
26	♂	Pc 3	12.3	4.1	16	1,000	Pc 1	12.8	4.0	73
27	♀	Pc 1	9.3	3.3	43	1,800	Pc 0	12.9	4.2	
9	♂	Pc 3	11.7	3.7	89	1,000	Pc 1	12.1	4.3	162

earlier by Andersson (1950), contains 100 mg. of iron per 5 ml. of solution (1 ampule). The number of doses was determined according to instructions given by Agner and Andersson, with administration of 1,000 mg. of iron (10 doses in 10 days) to normalize the depot iron, and 180 mg. of iron per gram per cent; the hemoglobin level lay below the calculated normal hemoglobin levels of 13.6 Gm. per cent for men and 11.5 Gm. per cent for women. No serious side effects were obtained from the therapy. In some cases a general sense of bodily warmth, as well as heat and flushing of the face, was reported by the patients in connection with the injection. These side effects were avoided, however, by giving the injection more slowly. As a rule, the injection time for a 5 ml. ampule was five minutes. In all cases treated, a nor-

mal hemoglobin level was observed at the follow-up examination one month after the last injection. The material treated in this manner comprised twenty-seven patients, twenty-one with pronounced sideropenia and three with postcibal symptoms but normal serum iron values. One of the latter six patients was a woman with 10.7 Gm. per cent hemoglobin, 4,300,000 erythrocyte count, and 134 γ per cent serum iron. There was probably an error in the serum iron determination, which without doubt was low. She received treatment, and her condition improved appreciably. Another patient in the latter group was a man with extremely severe postcibal symptoms following B II partial gastrectomy three years earlier. At the time of examination he had completely normal blood values: 15.3 Gm. per cent hemoglobin, 5,700,000 erythrocyte count, and 146 γ per cent serum iron. At his insistence he was given, altogether, 1,000 mg. of iron intravenously, over a period of 10 days, and the effect was dramatic. From a condition of such distress from postcibal symptoms that he was unable to participate in social activities or to eat at a restaurant, he became completely symptom-free. The effect lasted six months, after which the symptoms reappeared. He still had normal blood values at that time, while the serum iron was 91 γ per cent. He received an additional 500 mg. of iron, and again became symptom-free. The other four patients with normal serum iron at the time treatment was instituted showed no improvement after therapy. The twenty-one cases of sideropenia and postcibal symptoms are presented in Table VII. These data show improvement in all cases but one, with fourteen patients becoming completely symptom-free. The posttherapeutic blood values given in the table and their effect with respect to the postcibal symptoms were determined at follow-up examinations between six months and one year after the termination of the treatment.

DISCUSSION

The possibility that there might be a relationship between the occurrence of anemia or sideropenia and the appearance of postcibal symptoms following partial gastrectomy has been pointed out earlier by Bruusgaard (1946), Fehr and Ott (1950), Lyngar (1950), Jasinski and Ott (1951), and Drablös, Lindén, and Skjelbred (1951). In 1954, in a monograph on the results of partial gastrectomy according to Billroth I and II, I also discussed the question and the alleged existence of such a relationship. The present investigation would seem to have demonstrated that such relationship does exist, and that patients with anemia and especially with sideropenia following partial gastrectomy are more frequently subject to postcibal symptoms than patients with normal serum iron and hemoglobin values. It has likewise been demonstrated that iron therapy, preferably administered intravenously because of the poor capacity for absorption in the postgastrectomy patient, can produce considerable improvement, even to the complete disappearance of symptoms. The mechanism of the effect of the iron deficiency in the origin of postcibal symptoms is not easy to explain, and thus far no investigation has been carried out with this in view. Considering the general assumption that

postcibal symptoms may be regarded as the response of the small intestine, and particularly of its mucosa, to a sufficiently intense nonspecific irritation, it may be assumed that the iron deficiency causes an increased sensitivity in the intestinal mucosa which may result in the higher frequency with which patients with iron deficiency exhibit postcibal symptoms after partial gastrectomy. This is supported also by the known fact that sideropenia gives rise to other epithelial changes in the nails, buccal mucosa, and so on (Heilmeyer and Plötner, 1937, Waldenström, 1944). This investigation has shown that iron deficiency manifested as sideropenia and hypochromic anemia is, without doubt, a factor contributing to the origin of the postcibal symptoms appearing after partial gastrectomy for peptic ulcer. Moreover, it has demonstrated that in the concurrent occurrence of anemia or sideropenia and postcibal symptoms following partial gastrectomy there is every reason to attempt to improve the patient's condition with well-planned and well-executed iron therapy.

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THE SURGERY OF ANNULAR PANCREAS

A Summary of Sixty Patients Operated Upon

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THE developmental anomaly first described by Alexander Ecker in 1862,[1] and named, by him, annular pancreas, had been considered rare until recent decades. Since Ecker's article appeared there has slowly accumulated an extensive bibliography on this interesting subject. Today we can list over ninety cases of annular pancreas, with sixty surgically treated. The importance of and the interest in this chapter of surgical pathology are demonstrated by the publication, particularly in the last decade, of accurate studies oriented especially to the clinical and radiologic interpretation and to the treatment of the disease itself. The diagnosis, which formerly was incidentally reported along with autopsy findings, is today a most accurate preoperative forecast. Operative mortality is rapidly diminishing, and results are, in most reports, gratifying.

The knowledge of the normal development of the pancreas is essential in order to explain the embryologic course of this malformation.

Lecco[2, 3] and others[4-11] have studied the embryologic developments in the region of the head of the pancreas and in the proximal duodenum most carefully. The pancreas develops from two outgrowths, one dorsal and one ventral, out of the gut destined to become the second portion of the duodenum. The dorsal outgrowth forms part of the head of the pancreas, its body, and the tail. The ventral outgrowth consists of two buds which embrace the common duct. Of these two, the left bud atrophies, while the right persists. With the development and rotation of the gut, the right ventral anlage together with the common duct moves dorsally and joins with the major dorsal outgrowth to form the complete head of the pancreas, enveloping, as it does so, the second portion of the duodenum. Both anlagen contain a main duct. The two ducts unite within the formed head of the pancreas and comprise the duct of Wirsung.

With this brief summary of the normal evolution of the pancreas, let us now examine briefly the principal theories concerning the formation of annular pancreas. The presence, in the pancreatic ring, of a duct which originates from the ventral anlage (seventeen cases out of twenty studied radiologically) is decidedly in favor of the hypothesis of Lecco. He considered the anomaly as derived from the adherence of the tip of the right ventral anlage to the duodenal wall. Consequently, during the dorsal migration, a bridge of pancreatic tissue forms around the duodenum. Baldwin[12] offered, instead, the hypothesis of

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the persistence and development of the left ventral anlage, from which point the annulus is formed. Tieken,[13] 1901, and Lerat,[14] 1910, offered the hypothesis of a ventral and dorsal hypertrophy of the pancreatic head and the consequent embracing of the second portion of the duodenum. Hill,[15] 1926, and Chapman and Mossman,[16] 1943, called attention to the pancreatic conformation in animals, and to the possibility of the formulation of an atavistic theory in the insurgence of the annular pancreas. Although the etiological pathogenesis of annular pancreas is still somewhat obscure, the theory of Lecco is at present the most favorably accepted by medical authors.

Macroscopically and microscopically, like the rest of the pancreas, the pancreatic ring may be completely normal. Some authors have described a picture of pancreatitis, of varying degree. Lehman,[17] 1942, described, in five out of ten operative patients, a chronic interstitial pancreatitis. The most common operative or autopsy finding has been that of duodenal obstruction, more or less marked, with dilatation of the proximal duodenum. Compression of the common duct has been reported in some. Others have reported the presence of gastroduodenal ulcerations. Finally, and not exceptionally, one may find the existence of other malformations, particularly in the gastrointestinal and the cardiovascular systems. Gross and Chisholm[18] calculated that these additional anomalies were found in approximately 20 per cent of the patients studied. One of our patients presented a mesenteric hernial defect.

The clinical symptoms of annular pancreas, in general, are presented by disturbances more or less marked by gastrointestinal obstruction, such as epigastric pain and distress, anorexia, nausea, and vomiting. In the newborn infant loss of weight and frequent meconium stools are most common. The intensity of signs and symptoms are in direct relation to the degree of obstruction to the second portion of the duodenum by the ring of pancreatic tissue. Depending upon this degree of obstruction, signs and symptoms in the infant or the adult may disappear for indeterminate periods, or may remain minor, only to be discovered at autopsy. Where obstruction of the common duct is described, the disease is serious. Immediate surgery alone can save such a patient.

The signs and symptoms summarize most cases of annular pancreas in three categories:

1. *Complete duodenal obstruction,* so marked as to necessitate surgery shortly after birth. The "double bubble" x-ray finding is now classical in this group.

2. *Incomplete or moderate duodenal obstruction,* where signs and symptoms of transient obstruction occur, with weeks or months between attacks. X-ray diagnosis here is most accurate during remissions.

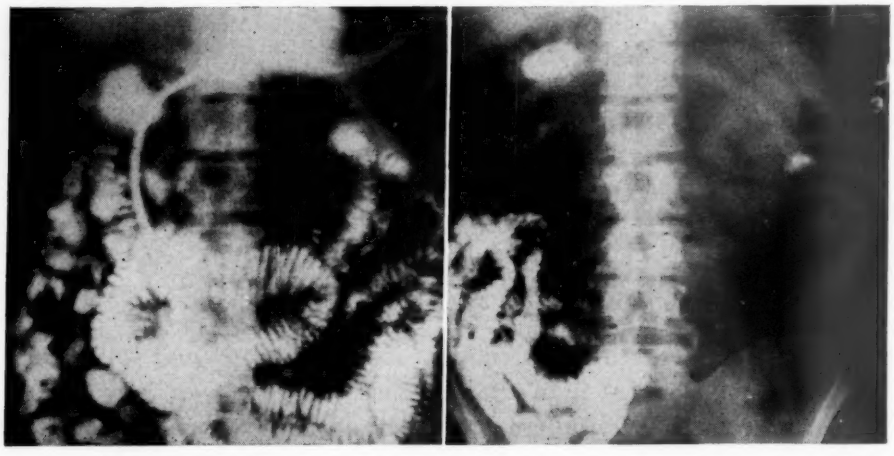
3. *Minimal duodenal obstruction,* which is an incidental finding at surgery or at autopsy.

The not infrequent coexistence of gastroduodenal ulcerative lesions can make diagnosis difficult, as the symptoms of these lesions may overshadow those of annular pancreas. Especially is this true where duodenal scarring, due to ulcer, complicates the radiologic findings.

Roentgenology has been the greatest aid in the formulation of accurate preoperative diagnosis. The characteristic sign of the "double bubble," produced by the dilatation of the duodenum proximal to the obstructed second portion, plus the gastric dilatation proximal to it, is easily recognized. The barium-emptying time varies with the degree of duodenal obstruction. The more moderate the obstruction, the more frequently must films be obtained after the barium swallow.

CASE REPORTS

CASE 1.—W. E. N., a 46-year-old man, was admitted to the Baptist Memorial Hospital with a diagnosis of chronic intestinal obstruction following a complete gastrointestinal study by his private physician, on Dec. 15, 1949. For as many years as he could remember he had had almost annual attacks of bloating, upper abdominal distention, nausea, and vomiting. At times, food had been vomited that had been eaten one or two days previously. There had been no visible distention or diarrhea, but periods of obstipation often preceded the attacks. His appetite had always been good, and, excepting for periods of one or two weeks of incapacity due to his spells of abdominal distress, he had always been regularly employed. Physical examination showed temperature 98.8° F., pulse 80, respiration 18, blood pressure



A. *B.*

Fig. 1.—*A*, Barium swallow, followed by small bowel enema, with Levin tube in upper jejunum. Note bulbous first and second portions of duodenum in upper left. Also note collection of barium ("mushroom") in upper right.

B, Three-hour-film, after withdrawal of Levin tube, showing retention in proximal duodenum. Note also isolated collection of barium still remaining in former mushroom area in upper right. This collection is probably barium still remaining in intramesenteric hernia in mid-jejunum.

128/82, and weight 191 pounds. The patient presented no remarkable physical findings in relation to his recent illness. He appeared to be entirely well, a well-developed, tall, well-nourished, intelligent man of middle age. Since upper abdominal disease was suspected, a barium swallow, followed by a small bowel enema of barium, revealed, in x-ray findings, only a bubble of barium in the proximal portions of the duodenum. This bubble did not disappear even after the passage of a duodenal tube. After duodenal suction it disappeared slowly (Fig. 1). A three-hour retention of the barium to a significant degree, in the proximal duodenum, plus a small pocket in the jejunum was noted. (See operative findings.)

At operation duodenal obstruction was found to be caused by a ring of pancreatic tissue which practically surrounded the mid-portion of the duodenum, narrowing the lumen

to approximately 1.5 to 2 cm. in diameter. The portion of the duodenum proximal to the obstruction measured approximately 7 to 8 cm. in diameter, being slightly edematous and thickened in comparison to its distal limb. The distal limb, fortunately, was of normal diameter (about 3.5 to 4 cm.) and was surprisingly freely movable. The obstructive band encircling the duodenum (Fig. 2) measured about 2 cm. in its narrowest width. Pancreatic tissue encroached both anteriorly and posteriorly except for a distance of about 1 cm., converging into a band of fibrous tissue, flat, thin, and rigid. The stomach and the duodenum distal to the obstruction (third and fourth portions) were normal. There were no ulcerations. An additional anomaly, found on careful examination of the remainder of the intestinal tract, was an intramesenteric hernial opening in the mid-portion of the jejunum (Fig. 1). It measured 5 cm. in diameter at its mouth, presenting a deep, well-formed cavity of mushroom form about 8 cm. in diameter and 5 cm. deep. The hernial opening was easily closed with interrupted No. 000 catgut gastrointestinal sutures. Because of the mobility of the immediately distal duodenum, a duodenoduodenostomy was performed anterior to the obstructing pancreatic ring. The new opening, internally, approximated 4 cm. in diameter. Postoperative recovery was uneventful. The patient was discharged on his seventh postoperative day. It is now four and one-half years since surgery has been performed. There has been no return of his former signs or symptoms.

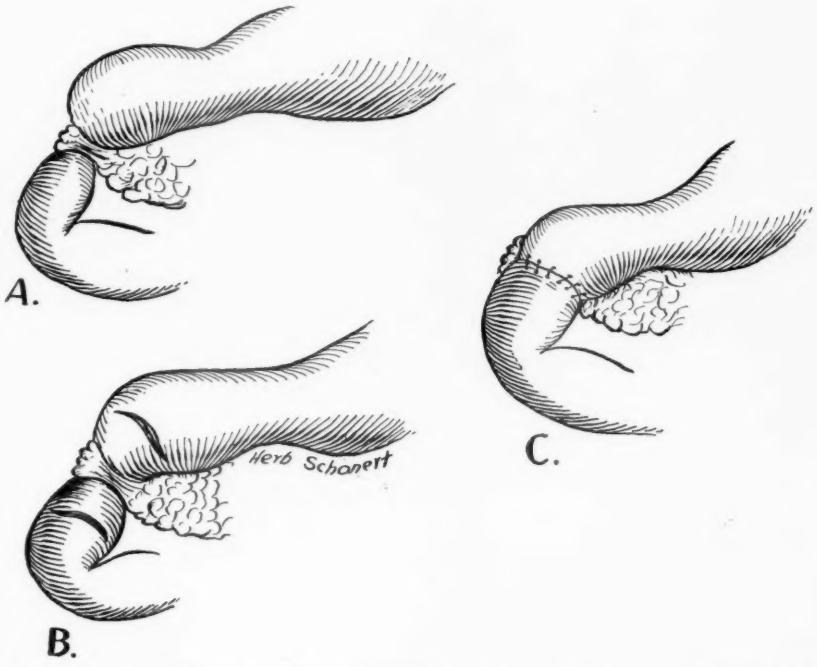


Fig. 2.—*A*, Appearance, as seen at operation, of annular pancreas. The major constricting anomaly is revealed as a thick pancreatic capsular band. *B*, Transverse incisions in proximal and distal loops of the duodenum. The distal loop was quite mobile. *C*, Completion of duodenoduodenostomy.

CASE 2.—M. B., was a 12-month-old boy, who, during his first week of life, had begun vomiting, not incessantly, but in great quantities, from time to time. It was never projectile. These vomiting spells would continue for a few days and then cease. Hardly a week passed, throughout his entire twelve months, without a prolonged period of vomiting for one or two days. Formulas were often changed without success. Weight gain was slow. At 12 months his weight was 22 pounds, 5 ounces, whereas at birth he weighed 7 pounds, 1 ounce. Con-

stipation always accompanied the attacks. X-ray examinations made in another large city revealed some gastric retention. Physical examination revealed a thin, but not emaciated, male infant, alert and bright. There was no dehydration nor did he appear ill. Otherwise, all vital signs and physical findings were normal. X-ray examination* revealed a 40 per cent retention of barium in the stomach after three hours. The duodenal cap and proximal loop were distended and filled with barium. It decreased as the stomach retention also subsided (Fig. 3). With such x-ray findings, the condition was diagnosed as annular pancreas and the patient was admitted to the Baptist Memorial Hospital for surgery. He was operated upon under open ether. A distended stomach, as well as a distended proximal duodenum, was found. An obstructing band of pancreatic tissue and capsule, approximately 1 cm. wide, was found. The ventral and dorsal heads of the pancreas surrounded about two-thirds

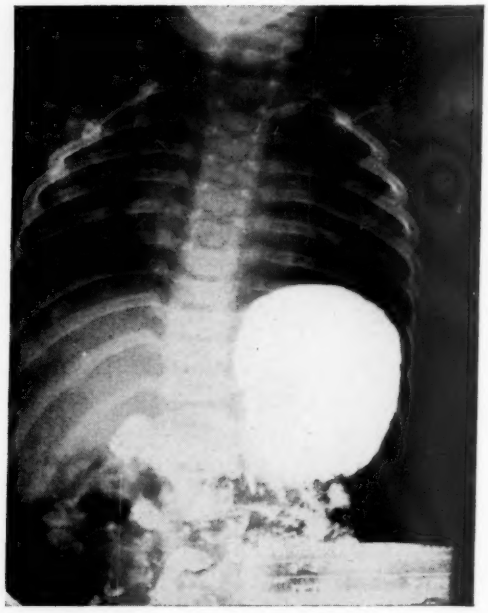


Fig. 3.—Three-hour film. Forty per cent retention in stomach. The duodenal cap and the proximal second portion are distended with barium. Incomplete but diagnostic "double bubble."

of the duodenal wall in its second portion, with pancreatic capsule, connecting the two heads, forming the central portion of the constricting band. Exploration of the remainder of the gastrointestinal tract revealed no disease. The pancreatic tissue appeared to be normal. A retrocolic duodenojejunostomy was performed between the proximal loop of the duodenum and jejunum (Fig. 4). Postoperative recovery and convalescence were uneventful. He was discharged on the fourth postoperative day. There have been no vomiting spells since operation. Six months have passed since surgery. He now weighs 26 pounds.

DISCUSSION

Our knowledge of this comparatively recently discovered anomaly has been augmented by the cooperation between pediatrician, roentgenologist, and surgeon. It has resulted in the saving of lives of newborn infants, as well as allaying the distress and incapacity of older infants, children, and adults.

*By Dr. Gray.

The ground work was laid by Ecker many years ago, to be brought into better embryologic light by Lecco, Baldwin, Tieken (Figs. 5 and 6), and others. The fruition of their labors is best epitomized by the careful clinical study of Lehman in 1942, which has spurred most of us to be on the lookout for this disease, especially in the newborn infant.

In reviewing the many case reports of surgery in this disease (Table I) one is struck by the number of different procedures adopted by various authors with ultimate success in the great majority. Apparently various complications at the

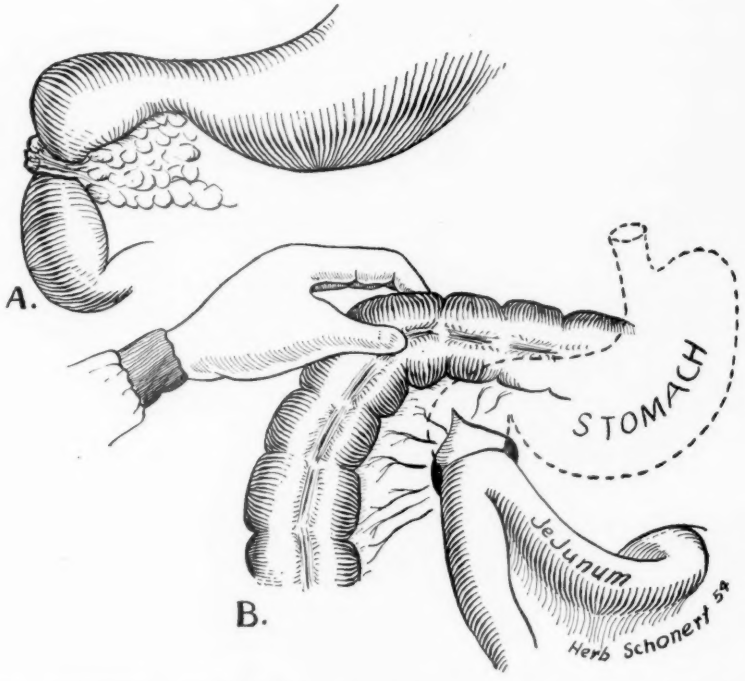


Fig. 4.—*A*, Appearance, as seen at operation, of annular pancreas. As in Fig. 2, the major constricting anomaly is found to be a thick pancreatic capsular band; *B*, the ideal operation of choice, a transmesocolic duodenojejunostomy, is completed.

site of the anomaly have been responsible. Where the annular pancreas presents a simple bandlike constriction, duodenojejunostomy seems now to be the operation of choice. Where a massive enlargement of the annulus precludes this procedure, a gastroenterostomy is successfully employed. These two procedures seem indicated most frequently in the newborn child and in the infant. Where pancreatic disease and obstruction to the duodenum both are to be found, subtotal gastric resection with gastrojejunostomy have been performed with success. In the presence of jaundice, a dangerous complication, due to common duct obstruction and pancreatitis, cholecystenterostomy has been suggested. We believe that the gall bladder should not be removed unless serious disease of that organ is present. If stones are present the gall bladder should be removed. In other instances, should jaundice arise, the gall bladder could be utilized as an important by-pass in the performance of cholecystenterostomy.

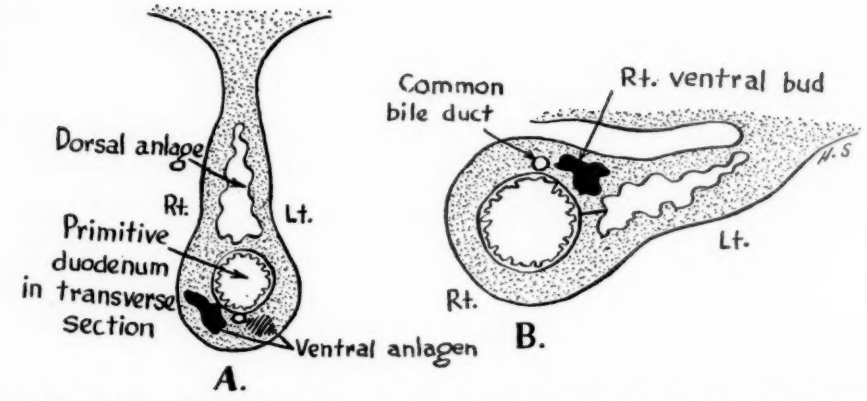


Fig. 5.—Diagrammatic presentation of normal pancreatic development (as modified from Anderson and Wapshaw[40]).

A, Reveals the dorsal anlage growing into the mesoduodenum. The two primordial anlagen of the ventral portion lie on either side of the common bile duct. The right (black) persists, while the left (shaded) atrophies or fuses with the right.

B, Reveals a later stage. As the duodenum and its mesentery swing to the right, the right ventral anlage and the common bile duct migrate dorsally and approach the larger dorsal pancreatic anlage.

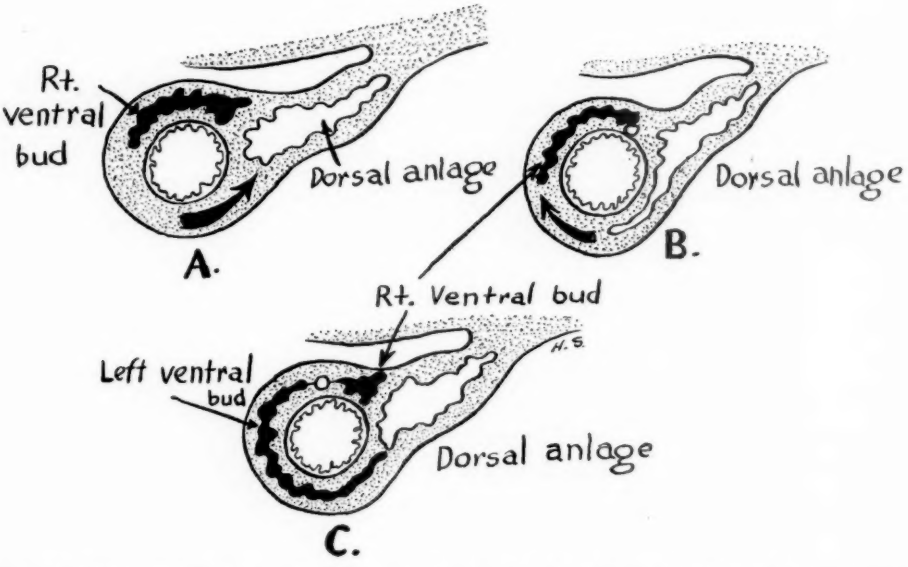


Fig. 6.—Diagrammatic presentations of theories of development of annular pancreas (as modified from Anderson and Wapshaw[40]).

A, Lecco's theory. Annulus results from the adherence of the right ventral bud near its point of origin.

B, Baldwin's theory. Annulus results from persistence and enlargement of the left ventral bud, with the duct of the annulus entering the common bile duct.

C, Tieken's theory. Annulus resulting from extensions from the right ventral and the dorsal anlagen.

TABLE I. SUMMARY OF SIXTY OPERATIONS FOR ANNULAR PANCREAS

SOURCE	DATE	AGE	SEX	OPERATION	RESULT	REMARKS
1. Vidal	1905	3 days	M	Posterior gastroenterostomy	Cured	Atresia of duodenum
2. dos Santos	1906	25 yr.	F	Posterior gastroenterostomy	Died	Diagnosis post mortem
3. Lerat	1908	46 yr.	F	Resection of pancreatic ring	Cured	Drainage for 13 days
4. Smetana	1928	74 yr.	M	Posterior gastroenterostomy	Died	Cancer of cystic duct—diagnosis post mortem
5. Howard	1930	46 yr.	F	Division of pancreatic ring	Cured	Pancreatic fistula requiring second operation for drainage
6. Brines	1930	35 yr.	M	Drainage of pancreas	Died	Diagnosis post mortem
7. Zech	1931	27 yr.	F	Heineke-Mikulicz duodenoplasty	Cured	Pancreatic fistula
8. Brines	1931	44 yr.	M	Posterior gastroenterostomy	Died	Diagnosis post mortem
9. Truelsen	1940	35 yr.	M	Posterior gastroenterostomy	Cured	
10. Lehman	1942	23 yr.	M	Partial resection of pancreatic ring	Recovered	Persistence of duodenal deformity by x-ray postoperatively
11. Gross and Chisholm	1944	3 days	F	Duodenojejunostomy	Cured	
12. Custer and Waugh	1944	74 yr.	M	Gastric resection with gastrojejunostomy	Cured	Also gastric ulcer
13. Goldyne and Carlson	1946	26 yr.	M	Partial resection of pancreatic ring	Cured	
14. Nedelec	1946	17 yr.	M	Posterior gastroenterostomy	Cured	
15. Brown, Bingham, and Cronk	1948	53 yr.	M	Division of pancreatic ring duodenostomy	Died	Subdiaphragmatic abscess. Duodenal fistula
16. Burger and Alrich	1949	4 days	F	Partial resection of pancreatic ring. Heineke-Mikulicz duodenoplasty	Died	
17. Ohlmacher and Marshall	1950	27 yr.	M	Gastric resection and gastrojejunostomy	Cured	
18. Baker and Wilhelm	1950	59 yr.	M	Gastric resection and gastro- and duodenojejunostomy	Cured	Also gastric ulcer
19. Ravitch and Woods	1950	57 yr.	M	Partial resection of pancreatic ring. Duodenojejunostomy 37 days later	Cured	
20. Ravitch and Woods	1950	3 days	F	Duodenojejunostomy	Cured	
21. Orts and Duenas	1950	19 yr.	M	Subtotal gastrectomy. Gastroduodenostomy	Cured	Also duodenal ulcer
22. Ravitch and Woods	1950	8 days	M	Gastroduodenostomy	Cured	Malrotation of intestine; duodenal atresia
23. Haden	1950	3 yr.	M	Partial resection of pancreatic ring	Recovered	Persistence of duodenal obstruction
24. Conroy and Woelfel	1951	30 yr.	M	Division of pancreatic ring	Cured	
25. Conroy and Woelfel	1951	26 yr.	F	Gastroenterostomy	Cured	
26. Payne	1951	33 yr.	M	Partial resection of pancreatic ring	Recovered	Persistence of duodenal obstruction

(Table I continued on following page.)

TABLE I. CONT'D

SOURCE	DATE	AGE	SEX	OPERATION	RESULT	REMARKS
27. Cattell	1951	36 yr.	M	Division of pancreatic ring. Gastric resection	Cured	Also had duodenal ulcer postoperative jejunal fistula. Roux exclusion and resection of fistula
28. Anderson and Wapshaw	1951	32 yr.	F	Resection of pancreatic ring	Cured	
29. Wakeley	1951	36 yr.	M	Resection of pancreatic ring	Cured	
30. Bickford and Williamson	1951	25 yr.	M	Posterior gastroenterostomy	Cured	
31. Silvis	1952	37 yr.	M	Partial resection of pancreatic ring	Cured	Pancreatic fistula healed spontaneously on forty-seventh postoperative day
32. Warren	1952	37 yr.	M	Gastric resection and excision of anterior part of ring	Cured	Pancreatic-jejunal fistula. Had duodenal ulcer
33. Warren	1952	22 yr.	F	Cholecystectomy and choledochostomy	Recovered	Had previous division of stomach antrum and gastroenterostomy
34. Warren	1952	41 yr.	F	Gastroenterostomy. Vagotomy	Cured	
35. Castleton, Morris, and Kukral	1952	41 yr.	F	Posterior gastroenterostomy. Choledochostomy	Cured	Concomitant amebiasis, chronic ulcerative colitis, severe pancreatitis
36. Bovill and Bailey	1952	26 yr.	M	Subtotal gastric resection	Cured	Marked hypoplasia of the first portion of duodenum
37. Shapiro, Dzurik, and Gerrish	1952	7 days	F	Duodenojejunostomy	Cured	Duodenal atresia
38. Shapiro, Dzurik, and Gerrish	1952	17 days	M	Gastroduodenostomy	Cured	Mongolism
39. Shapiro, Dzurik, and Gerrish	1952	3 days	F	Duodenoduodenostomy	Cured	Duodenal atresia
40. Shapiro, Dzurik, and Gerrish	1952	10 days	M	Duodenoduodenostomy	Died	Mongolism. Incomplete rotation of colon
41. Johner	1952	37 yr.	F	Pyloroplasty	Cured	
42. Ribeiro and Horta	1952	56 yr.	F	Partial resection of pancreatic ring. Heineke-Mikulicz procedure	Cured	
43. McGee and Black	1953	62 yr.	M	Gastroenterostomy	Cured	
44. Goldyne and Carlson	1953	54 yr.	F	Resection of band and reflection of pancreatic ring	Recovered	Persistence of duodenal obstruction and massive gastric hemorrhage 2 yr. after operation
45. Wilson and Bushart	1953	30 days	M	Posterior gastroenterostomy	Cured	

46. Wilson and Bushart	1953	20 mo.	M	Duodenojejunostomy	Cured	Aspiration pneumonia
47. Wilson and Bushart	1953	5 days	M	Duodenojejunostomy	Died	Persistence of duodenal obstruction
48. McPhee	1953	26 yr.	M	Resection of pancreatic ring	Recovered	
49. Swynnerton and Tanner	1953	30 yr.	M	Subhiatal vagotomy. Heineke-Mikulicz pyloroplasty	Cured	
50. Tomsykoski, Stevens, and Izzo	1953	48 yr.	M	Gastric resection and gastrojejunostomy	Cured	
51. Monsaingeon and Bernard	1953	50 yr.	F	Division of pancreatic ring. Gastric resection	Cured	
52. Gillette and Lynch	1954	64 yr.	M	Duodenojejunostomy	Cured	
53. Kiesewetter and Koop	1954	4 days	F	Duodenojejunostomy	Died	Mongolism gastrojejunostomy 11 days later
54. Kiesewetter and Koop	1954	18 days	M	Division of ring	Died	
55. Kiesewetter and Koop	1954	6 days	F	Gastrojejunostomy	Died	Esophageal atresia and tracheoesophageal fistula
56. Kiesewetter and Koop	1954	5 days	M	Gastrojejunostomy	Died	Malrotation of colon Atresia of duodenum
57. Kiesewetter and Koop	1954	3 mo.	F	Gastric resection	Cured	Malrotation of colon. Duodenal bands
58. Kiesewetter and Koop	1954	3 days	F	Duodenojejunostomy	Cured	
59. Tendler and Ciuti	1954	42 yr.	M	Duodenoduodenostomy	Cured	Intramesenteric hernia (jejunal)
60. Tendler and Ciuti	1954	1 yr.	M	Duodenojejunostomy	Cured	

In Case 1, a Finney duodenoduodenostomy was ideal because of the easy mobility of the distal portion of the duodenum (Fig. 2). In Case 2, the "classical" retrocolic duodenojejunostomy produced the desired result (Fig. 4).

It is agreed that pancreatic resections are always fraught with danger, yet in most cases reported results have been good. We believe that sectioning of the annulus should be avoided, however, when possible, since resulting healing processes often produce sufficient scarring and stenosis to require reoperation because of persisting or recurring signs and symptoms. Lehman, in discussing Payne's paper,[38] emphasized this point.

SUMMARY AND CONCLUSIONS

1. A brief review of the embryology, anatomy, and roentgenology of annular pancreas is presented.

2. Since 1905, sixty surgically treated cases have been found in the literature with an over-all mortality rate of 20 per cent (Table II).

TABLE II

Total number of patients operated upon		60
Cured	42	
Surgical recoveries	6	
Died	12	
Over-all operative mortality rate		20 per cent
Age of patients		
1 day to 30 days	16	
1 month to 1 year	2	
1 year to 10 years	3	
10 years to 20 years	2	
20 years to 30 years	12	
30 years to 40 years	9	
40 years to 50 years	7	
50 years to 60 years	5	
60 years to 70 years	2	
Over 70 years	2	
Total no. of patients	60	

There were 38 males and 22 females in the series.

3. Since the presenting lesion may be complicated by more than the usual simple constricting band or annulus of pancreatic tissue, the choice of operative procedure may be varied, with ultimate good result. This operative procedure may vary, as well, in the newborn infant, the older child, or the adult.

4. Two cases are presented, both of chronic duodenal obstruction due to annular pancreas, one in a 1-year-old boy, the other in a 46-year-old man.

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TREATMENT OF INTUSSUSCEPTION IN CHILDREN

A Brief Survey Based on 1,838 Danish Cases (I. 1,042 Cases 1928-1935. II. 796 Cases 1944-1949)

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It is the surgeon who is to treat the intussusception from the very beginning, but he is not to treat it with laparotomy from the very beginning.

[Wichmann, 1893.]

AFTER a quarter of a century, members of the medical profession everywhere outside Scandinavia are now discussing the potentialities of reduction of intussusception in children by barium enema.

In Denmark, the barium enema method is no longer discussed; here it has gained almost universal acceptance and is in common use. Only in exceptional cases do the surgeons primarily take recourse to operation, which appears from the fact that one of us (H. H.), in collecting data on all cases treated in all hospitals in this country, found that the barium enema method was used in 96.7 per cent of all instances of suspected intussusception in children.

For almost eighty years, conservative treatment of intussusception in children has been seriously contemplated and used in this country. In this connection it may be of interest to mention a few names:

Water enema: Hirschsprung, 1876; Wichmann, 1893.

Taxis, massage: Monrad, 1926.

Barium enema: Arntzen and Helsted,*** 1928, 1929; Jakob Nordentoft,*** 1928, 1929, 1930, 1942; J. Munck Nordentoft, 1943, 1950; Herbert Hansen, 1953.

The ardent discussion concerning conservative versus surgical treatment had largely come to an end in Denmark when the barium enema method was introduced. The reason that it has not come into common use in Anglo-Saxon countries is presumably that the old methods had already been abandoned before the administration of barium enema under fluoroscopic control was introduced, independently, by Olsson and Pallin, Pouliquen and De la Marnierre, Retan, and Stephens in 1927. The publication of certain series showing good results of surgical treatment must also be assumed to have been a contributory factor in this development.

As already mentioned, the barium enema method has gained almost universal acceptance in Denmark. During the years from 1928 to 1935 the use of the method increased from 10 to 90 per cent of all cases of intussusception in

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children (Munck Nordentoft). This development is due especially to the fact that the accuracy has been substantially increased with regard to both diagnosis and subsequent confirmation of adequate reduction.

Many hundred studies on intussusception in children which have been published during the course of time have made the general practitioner familiar with the clinical manifestations of the disease. Almost 80 per cent of all cases are admitted to hospital within the first twenty-four hours after the onset (in Series I [1928-1935], 697 of 944, or 74 per cent; in Series II [1944-1949], 570 of 723, or 79 per cent); 60 per cent enter the hospital even within the first twelve hours.

In this country, children with intussusception are admitted to the departments of surgery, but the surgeons primarily refer these cases to the departments of radiology,* where reduction by barium enema is attempted. The patient is subjected to operation only if the attempt proves unsuccessful or if the reduction seems questionable.

The evaluation of the results of conservative treatment is made by surgical and radiologic collaboration, whereas the decision as to further therapeutic measures is taken by the surgeon.

TABLE I. MORTALITY RELATED TO METHODS OF TREATMENT

	SERIES I (J. MUNCK NORDENTOFT) 1,042 CASES FROM 1928-1935			SERIES II (HERBERT HANSEN) 796 CASES FROM 1944-1949 (ALL DANISH CASES FROM THE PERIOD)		
	CASES	DEATHS	MORTALITY RATE	CASES	DEATHS	MORTALITY RATE
Barium enema	204	12		413	2	
Secondary operation following barium enema	215*	45		302‡	50	
	419	57	13.6	715	52	7.3
Primary operation	450	116	25.8	74	14	18.9
Conservative methods other than barium enema (massage, water enema)	92	3				
Secondary operation	74†	21				
	166	24	14.5			
No treatment	7	5		7	7	
Total	1,042	202	19.4	796	73	9.2

*The intussusception was found to be reduced at operation in 16 cases (one of these, an infant, aged 7 months, died in hyperthermia on the first postoperative day).

†The intussusception was found to be reduced at operation in 6 cases (no deaths).

‡The intussusception was found to be reduced at operation in 53 cases (one of these patients died on the fifth postoperative day due to complete rupture of the wound).

COLLECTED SERIES

Series I (J. Munck Nordentoft)—1,041 cases from the years 1928 to 1935, inclusive, from most, but not all, Danish hospitals.† It may be estimated that about 150 cases were treated annually during this eight-year period in all

*In Denmark, the departments of radiology and surgery always lie in close relation to each other, usually within the same block of buildings.

†In 1943, detailed information of 440 of these 1,041 cases had been obtained from the surgical departments in this country; since that time the pertinent data of another 601 cases from the same period have been collected.

Danish hospitals. Barium enema was administered in a total of 419 cases; other conservative procedures (water enema, massage) were used in 165 cases (particularly during the first years of the period, but at some hospitals throughout the entire period). Thus, conservative treatment was used in 584 cases (56.5 per cent), primary operation in 450 cases (43.5 per cent), while 7 patients did not receive any treatment.

Series II (Herbert Hansen)—796 cases from the years 1944 to 1949, inclusive, which represent all cases of intussusception in children from all Danish hospitals during this six-year period; annual average about 135 cases.* Barium enema was used in 715 cases (91 per cent); other conservative methods were no longer used. Primary operation was employed only in 74 cases (9 per cent), namely, (a) 25 cases with a diagnosis of intussusception (3 deaths—12 per cent), and (b) 49 cases diagnosed as appendicitis, and so forth (11 deaths—22.4 per cent).

Thus, barium enema was used in 722 of 747 cases (that is, 96.7 per cent) in which intussusception was suspected. Seven patients did not receive any treatment.

In both series, the numbers of cases are minimum figures, as all instances in which unquestionable criteria for the diagnosis were not available were excluded.

DISCUSSION

The most essential objection to the conservative method, as voiced particularly by British and American surgeons, is that they distrust what they consider to be a blind procedure; they fear that gangrenous bowel may be reduced; that the intestine may be ruptured; or that some specific causative lesion may pass unrecognized. They find that hydrostatic pressure reduction is a tedious business that may cause serious delay in a possible operation.

Gross and Ware emphasized that attempted reduction by barium enema should never be done except with the consent of, and in the presence of, the surgeon who must accept the responsibility of operating on the child if the reduction by hydrostatic pressure proves unsuccessful. They raised the objection to the method that many of these patients later come to operative reduction because of irreducibility or because of uncertainty of complete reduction. Although their view seems entirely unwarranted (cf. Hellmer), they found the method useless when a portion of the intussusception is above the ileocecal valve. However, certain surgeons admit that it is of great importance that the intussusception be reduced as much as possible before the operation.

Finally, it is claimed that the frequency of recurrence is higher after conservative than after surgical treatment.

The objection that precious time is lost can scarcely be taken seriously. The roentgen examination rarely takes more than one hour and, if necessary, the barium enema may be given while the last preparations in the operating room are being made—"while the surgeon is washing his hands" (Bonomini).

*Population in Denmark:
1930: 3,550,656, including 973,141 children under 14 years.
1945: 4,045,232, including 996,882 children under 14 years.

It is absolutely wrong to say that the procedure is blind. As already pointed out, a diagnosis of intussusception may almost invariably be made with great accuracy, and the same applies to the confirmation of a successfully accomplished reduction.

Rupture of the intestine and reduction of gangrenous bowel will be a very rare occurrence if only the proper technique is used, and provided that the intussusception has not been left untreated for too long a period.

Rupture of the intestine occurred once in Series I, comprising a total of 419 barium enemas. The patient was an infant, aged 9 months, with intussusception of about forty-eight hours' duration and signs of pneumonia, in whom conservative reduction was attempted at all costs. In Series II, comprising a total of 715 barium enemas, rupture of the intestine occurred in three patients. In all three cases symptoms had persisted for more than forty-eight hours and the patients were severely affected on admission; conservative treatment proved unsuccessful and death ensued a few hours after subsequent laparotomy.

Among the 204 children in Series I who were treated exclusively with barium enema, twelve deaths occurred (none of the dead were over 9 months of age). Autopsy revealed intussusception of the small intestine in four cases and presumed anesthetic pneumonia in one. Among the 413 children in Series II who were treated exclusively with barium enema, only two deaths occurred. One child, whose symptoms had persisted for more than seventy-two hours, died three hours after the administration of the enema; autopsy was not performed. On the day following the barium enema reduction, the other child had a copious, blood-tinged stool and became progressively weaker. In spite of this the patient was only kept under observation and death occurred two days later. Autopsy revealed ileocecal intussusception, probably a recurrence (or incomplete reduction ?). Thus, in Series II the latter case was the only one in which there is a possibility that a gangrenous bowel was reduced, but its actual occurrence was not proved.

While it is known that intussusception of the small intestine passed unrecognized after administration of barium enema in several cases in Series I, this occurred only once in Series II. In the case concerned, roentgen examination with barium enema showed normal conditions, but in spite of the fact that gas-distended loops of the small intestine were demonstrated roentgenographically, no further treatment was given and the patient died. Autopsy showed intussusception of the small intestine.

It is of interest to consider the length of the interval which was allowed to elapse between the administration of the barium enema and a possible operation.

Of the 215 patients in Series I treated with barium enema, 184 (85.6 per cent) were subjected to operation within the first five hours after attempted reduction by barium enema; the corresponding figures from Series II were 287 (95 per cent) of 302 patients.

In Series I, 16 (7.4 per cent) of the 215 patients were subjected to operation twenty-four hours or more after the enema; the corresponding figures from Series II were 8 (2.6 per cent) of 302 patients.

The intussusception was found to be reduced at subsequent laparotomy in 16 (7.4 per cent) of the 215 patients in Series I, and in not less than 53 (17.5 per cent) of the 302 cases in Series II (cf. Table I).

These figures show that the surgeons in Series I have been inclined to "chance it," while those in Series II have resorted to operation at an earlier time and been less hesitant with laparotomy; in other words, a more cautious attitude had been adopted.

Concerning the possibility that lesions such as polyps or Meckel's diverticula, and so forth, might be overlooked, Ravitch and Morgan expressed the view that these lesions in childhood are not in themselves dangerous, even if they escape recognition for a time. The majority of cases of intussusception are encountered in infants, whereas polyps and other intestinal lesions are most common in slightly older children.

The pathologic conditions observed in the patients of our series are listed in Table II.

TABLE II. PATHOLOGIC CONDITIONS RESPONSIBLE FOR THE INTUSSUSCEPTION, DISCLOSED AT OPERATION

	SERIES I (J. MUNCK NORDENTOFT) 1928-1935		SERIES II (HERBERT HANSEN) 1944-1949	
Age, in years	Under 2	2 or over	Under 2	2 or over
Number of cases	666	376	504	292
Number of operations	479	260	222	154
Cause of intussusception				
Meckel's diverticulum	5	16	15	22
Benign tumor (polyp)	2*	8	3	2
Enterocystoma			1	
"Cyst"	1			1
Lymphosarcoma				1
Ectopic pancreatic tissue				1
Total	8 (1.7%)	24 (9.2%)	19 (8.5%)	27 (17.5%)

*One revealed at autopsy (barium enema the only form of treatment).

While Series I is in agreement with the view expressed by Ravitch and Morgan (pathologic changes are five to six times as frequent in children over 2 years as in younger children), the conditions revealed in Series II differ essentially in that pathologic changes are only twice as frequent in children over 2 years as in those under that age.

A possible explanation for this difference in our two series is that with the improved operative technique the surgeons can now afford a more detailed disentanglement of the intestinal conditions, while previously intraperitoneal reduction was done to reduce the operating time to the greatest possible extent.

It is commonly claimed that the barium enema method involves a greater risk of recurrence than does operation, and this is no doubt correct. Unfortunately, it is extremely difficult to evaluate this problem on the basis of the

collected series, in which it must be presumed that the return of symptoms during the first few days after the treatment is due rather to incomplete conservative reduction than to actual recurrence in the sense that a new invagination has developed after complete reduction of the first.

As this problem is highly significant, we intend to present our experience in this field after a further analysis of our series.

Of the factors in favor of conservative treatment may be mentioned that the hospital stay is reduced in length; the patients are spared the risks inherent to anesthesia and laparotomy, with attendant complications and higher morbidity as measured by fever, vomiting, abdominal distention, wound infection, and, possibly, the subsequent occurrence of intestinal obstruction. Thus, Kahle reported that ileus due to adhesions developed in four of his fifty-four operated patients. Such cases did also occur in our series, but they have not been subjected to a closer analysis. Finally, the opinion has been voiced by Ravitch and others that hydrostatic pressure reduction is definitely less traumatic to the bowel than manual reduction at open operation.

Anesthesia was used in many cases in Series I, but only in a few in Series II. Our case material thus confirms the prevalent opinion that anesthesia is superfluous.

MORTALITY AND ITS DETERMINING FACTORS

The causes of the steadily falling mortality figures may be sought, *inter alia,* in the general progress of medical science.

The majority of deaths in Series II occurred among children who were severely affected on admission. Judging from the clinical records, they were already in a hopeless condition when taken to hospital. In such cases a therapeutic barium enema is scarcely advisable. Measures aimed at relieving the shock state must be taken without delay.

As emphasized by all observers, the most important determining factor in the mortality is the length of the period allowed to elapse from the onset of the disease till treatment is instituted. In cases with a duration of symptoms of less than twenty-four hours the mortality should be zero (Hellmer).

As will be seen from Table I, the mortality rate disclosed in Series II was 9.2 per cent. This figure bears comparison with most of the comprehensive series published during recent years, but nevertheless it must still be considered to be too high. The importance of the duration of symptoms as related to mortality is clearly illustrated in Table III. However, the possibility cannot be excluded that some of the patients with a long duration of symptoms may have suffered from chronically recurring intussusception, but this assumption cannot be proved on the basis of the material available.

The advances which have been made in anesthetic and operative techniques during recent years are also of importance. Snyder, Kraus, and Chaffin expressed the opinion that one of the fundamental principles which had led to a reduced mortality in their series was the institution of measures directed toward correcting the alteration of body economy produced by the intussusception. These alterations are: (1) low mechanical obstruction with attendant

TABLE III. MORTALITY RELATED TO DURATION OF SYMPTOMS

DURATION, IN HOURS	SERIES I (J. MUNCK NORDENTOFT) 1928-1935			SERIES II (HERBERT HANSEN) 1944-1949		
	CASES	DEATHS	MORTALITY RATE	CASES	DEATHS	RATE MORTALITY
Less than 24	698	82	11.7	588	18	3.1
More than 24	247	95	38.5	208	55	26.4
Total	945*	177		796	73	

*The duration was not specified in 97 cases.

loss of water and electrolytes; (2) blood loss into the bowel and into the damaged tissues; (3) a localized lowering of the defense mechanism against infection.

Other determining factors are the risk of overlooking nonviable intestinal tissue and failing surgical judgment in the difficult decision of whether resection should be performed or if it may be justifiable to take the risks of leaving the injured bowel in the abdomen.

TECHNIQUE OF BARIUM ENEMA REDUCTION

It is not the purpose of this study to give a detailed account of the technique, which we have described elsewhere, but we want to give a brief survey of the procedure usually employed in Aalborg County Hospital.

(a) Before the administration of the enema, plain films of the abdomen are taken in both the dorsal and the erect positions in order to assess the degree of intestinal obstruction and, if possible, the type of intussusception.

(b) Diagnostic enema is given under low pressure and constant fluoroscopic control with a small field. When the intussusception figure is found, this is studied and photographed.

(c) Therapeutic enema is then administered under gradually increased pressure up to a column of, say, three to four feet. In cases of a duration of less than twenty-four hours, the pressure may, if necessary, be increased to four feet, six inches or more, but must never exceed six feet. The anus is occluded by a metal or ebonite obturator, or the like.

Hellmer was right when he said, "Attach the greatest importance to the nurse who assists ad anum. . . . This assistance is . . . quite as important for a successful result as the work of the roentgenologist."

When the reduction is almost complete, the cecum, particularly its medial aspect at the ileocecal valve, represents the crucial point. The most important radiologic signs of reduction are: (1) complete filling of the cecum and (2) distinct inflow into the ileum.

(d) It is very important to take postevacuation films of the colon, because these provide the best possibility of evaluating the conditions, irrespective of success or failure of the reduction.

(e) If there is any doubt as to the success, the barium enema may be repeated once or several times and further roentgenograms may be taken.

According to Hellmer, it is possible without the use of anesthesia to obtain inflow into the small intestine in all cases in which the intussusception has been reduced. This

result is presumably due to the use of repeated enemas given immediately during the stay in the roentgen department. By one short enema it seems possible to obtain inflow into the small intestine in only about 40 per cent of the cases.

(f) If it is doubtful whether reduction has been accomplished, a charcoal tablet dissolved in water may be given by mouth. If charcoal particles can be recovered by a water enema given five hours later, this proves at least that intestinal passage has been restored (Hipsley).

(g) If there is any doubt as to the completeness of reduction, as there must always be if the contrast medium has failed to enter into the small intestine, operation is indicated. In patients who have been taken to hospital early in the disease, an expectant attitude may be adopted, but only for a few hours.

(h) Postexamination care is of great importance. If attacks of colic or vomiting recur, further roentgen examination or operation is indicated. In our experience, apparent improvement often occurs in cases in which complete reduction has not been accomplished. Even though the child seems to have improved, begins to take feedings, or falls into sleep, these signs do not prove, beyond doubt, the completeness of the reduction. Clinical improvement is a deceptive sign. The roentgenographic signs of complete reduction are of paramount importance.

CONCLUDING REMARKS

In conclusion, we want to emphasize the importance of:

(a) Educational campaigns aimed at earlier hospitalization of patients for diagnosis and treatment.

(b) Provision of facilities for immediate examination and treatment by experienced radiologists.

(c) A friendly attitude toward the nonoperative treatment of intussusception on the part of all those concerned.

(d) A purposeful, energetic, and seriously intended attempt at reduction by barium enema in all suitable cases, that is, in at least all cases of a duration of less than twenty-four hours.

The "either-or" of earlier years in Denmark has now been superseded by an attitude of "both-and." That the barium enema method is used as a routine measure is due particularly to the fact that the experience and skill of the radiologists, both with regard to the diagnosis of intussusception and the subsequent confirmation of its successful reduction, have been greatly increased.

In this country intussusception is still treated by the surgeons, who primarily refer their young patients to the roentgen department with a view to barium enema reduction. Surgical measures are required only if this method fails, or if the result is questionable.

SUMMARY

The importance of barium enema in the treatment of intussusception in children is assessed on the basis of two comprehensive series from Danish hospitals, namely, (I) from 1928-1935 and (II) from 1944-1949.

Series II shows that after the lapse of about fifteen years barium enema is used in about 97 per cent of the cases in which intussusception is suspected beforehand, and that about 80 per cent of the patients are treated within the first twenty-four hours after the onset of the disease. Although the method is used far more critically than in the years immediately following its advent (in 1927), the percentage of successful reductions accomplished by the barium enema method has increased from 49 to 58; during the same period the mortality has been halved (19.4 per cent versus 9.2 per cent).

The most essential details of the two series are reported, and a brief survey is given of the technique of examination and reduction which we use.

In Denmark, it is usually the surgeon who conducts the treatment and refers the patient with intussusception to the roentgen department of the hospital for examination and reduction by barium enema.

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A NOTE ON THE INCIDENCE AND POSSIBLE SIGNIFICANCE OF VALVES IN THE INTERNAL JUGULAR VEIN

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DIRECT measurements of spinal fluid pressure and internal jugular vein pressure made during anesthesia often show a disproportionate rise of the former. (Fig. 1.) While investigating this discrepancy, it was postulated that the valve mechanism in the internal jugular vein might be responsible. The existence of valves at the inferior bulb of the internal jugular vein was noted by Spalteholtz,[1] who commented that "a little above its termination it presents a spindle shaped dilatation, the 'bulbous v. jugularis inferior,' which is closed

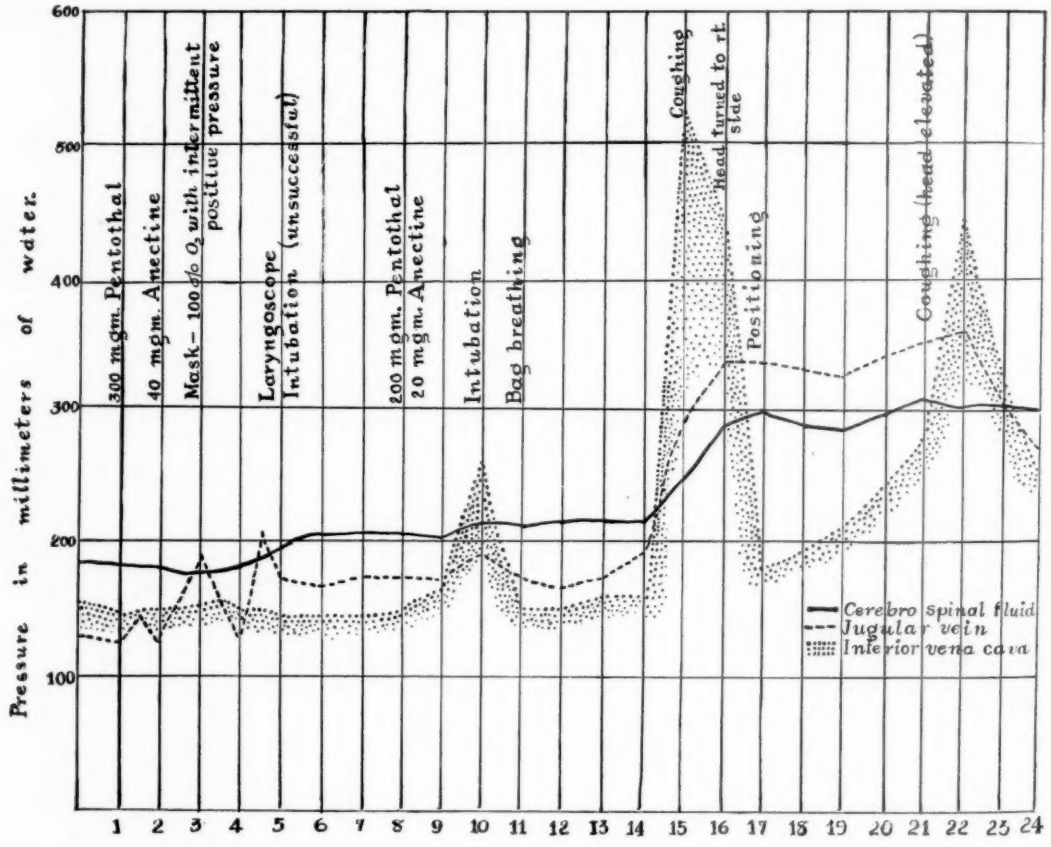

Fig. 1.—Chart showing pressure changes in the spinal fluid, internal jugular vein, and inferior vena cava in a patient during induction of anesthesia. Note that on three occasions the pressure rose higher in the inferior vena cava than in internal jugular vein.

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above by a single or double valve.'' Piersol[2] also commented on these valves, and suggested their role in preventing a back pressure effect. It was the purpose of the present investigation to determine the relative frequency, size, and possible functions of these valves.

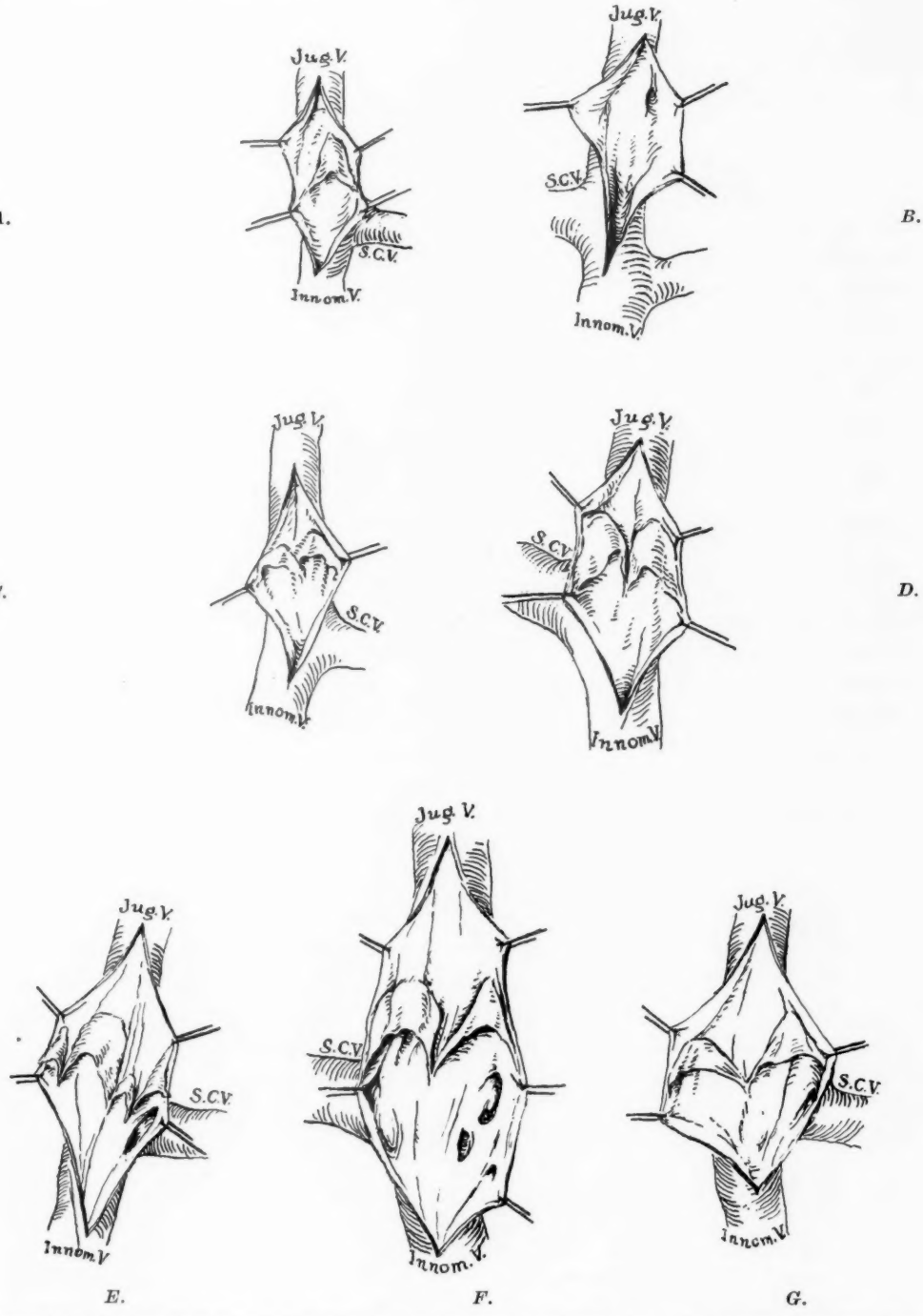

Fig. 2.—Artist's drawing of valves seen in the internal jugular vein. For description see text. *Jug. V.*, Internal jugular vein. *Innom. V.*, Innominate vein. *S.C.V.*, Superior vena cava.

Dissections of the internal jugular vein were carried out in autopsy and cadaver material. Forty-seven internal jugular veins were examined, twenty-eight right and nineteen left. (Table I.) One specimen only was devoid of valves. (Fig. 2, *B*.) A bicuspid valve was found in the majority of cases, thirty-two of the forty-seven (Fig. 2, *C, D, F, G*), while single valves (*A*) and tricuspid valves (*E*) were present eight and six times, respectively. The side examined did not appreciably alter the findings with respect to number of valves, except that five of the six tricuspid valves were right-sided. In almost every instance, the valves were so located that their free edges were within the proximal centimeter of the vein. Considerable variation in the size of the valves was noted, and thus, there was presumably a varied effectiveness with which they could act to occlude the lumen. Studies made using latex and paraffin to produce casts of the lumen indicated that approximately two-thirds of the cross-sectional area of the vein is the average portion occluded, although in several it appeared that the closure might have been almost complete.

TABLE I. SHOWING THE NUMBER OF VALVES FOUND IN FORTY-SEVEN DISSECTIONS OF THE INTERNAL JUGULAR VEIN

	NO VALVE	SINGLE	BICUSPID	TRICUSPID	TOTAL
Right	1	5	17	5	28
Left	0	3	15	1	19
Total	1	8	32	6	47

The function of these valves would appear to be that of a "baffle," thus diminishing sudden back thrusts of pressure in the internal jugular system on coughing, sneezing, and so on. Results of actual measurements of venous pressures from the internal jugular vein and inferior vena cava, with simultaneous spinal fluid pressures, will be reported subsequently. The existence of an effective jugular vein baffle should be borne in mind in accounting for at least part of the oft-observed discrepancy between pressure increases in the spinal fluid, as compared to those of the internal jugular vein.

SUMMARY

Examination of forty-seven internal jugular veins in the cadaver revealed the presence of one or more valves in all but one. These were situated just above the confluence with the subclavian vein. All were directed toward the heart, as are those in the leg and arm veins; they do not, on the contrary, support a column of blood against gravity, but must serve as baffles against such waves of pressure as might be reflected into the internal jugular system by coughing, sneezing, or straining.

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SURGICAL TREATMENT OF ATRIAL SEPTAL DEFECTS

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THERE is considerable parallelism between patent ductus arteriosus, atrial septal defects, and ventricular septal defects. In each condition there is a left-to-right shunt and increased blood flow through the pulmonary circulation. In advanced cases evidence of pulmonary sclerosis and hypertension may be present. Admittedly, a certain number of patients suffering from each of these conditions live out their life span. However, this group is small as compared to those disabled or dying from their cardiac anomalies. Such individuals usually have small defects. Surgical treatment of patients with a patent ductus arteriosus is the accepted treatment of choice. There has been a delay in the surgical treatment of septal defects due mainly to the complexity of the surgical problems involved.

The surgical problems in the closure of septal defects have centered about the control of hemorrhage during intracardiac manipulation, visualization of the surgical field, maintenance of an adequate circulation and oxygenation, closure of the defect, and the prevention of complications such as ventricular fibrillation, cerebral or coronary anoxia, and air emboli. Fields of investigation have centered about the development of an effective but simple pump oxygenator and hypothermia to allow open surgical techniques, and the development of closed techniques as guided by the intracardiac finger.

As the surgeon has been devising techniques, the internist has been evaluating the indications and contraindications to surgical closure. Evaluation of such patients is not complete or even possible based on clinical impressions alone without the physiologic data obtained from cardiac catheterization studies. Altered cardiopulmonary dynamics will be revealed by such studies before clinical manifestations develop.

The increased blood flow through the atrial septal defect and hence through the lungs is accommodated initially by dilatation and increased tension of the pulmonary vascular bed. Later, sclerosis of the pulmonary vascular circulation develops which further increases the pulmonary hypertension. This increased pressure within the pulmonary circuit reflects itself in the right side of the heart with reduction in shunt flow as recognized by the reduction in the oxygen differential between the venae cavae and right auricle. This is evidence of impending danger rather than a suggestion that the amount of shunt flow is not significant.

If the left-to-right shunt is great enough, the pulmonary vascular tension eventually gives rise to mediosclerosis of the pulmonary vessels with further

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increase in the pulmonary hypertension. This increased pulmonary tension reflects itself in the right ventricle and right auricle until a stage may be reached where there may be reversal of shunt flow. Obviously, it is important that closure of the atrial septal defects be made before irreversible changes in the pulmonary circulation occur.

TABLE I. INTERATRIAL SEPTAL DEFECT

PATIENT	POSITION	PRESSURES (MM. HG)	O_2 CONTENT (VOL. %)
R. T. M-9	SVC		9.6
	RA	6/3.5	13.0
Art. sat.	RV	28/8	13.7
99.1%	PA	18/7	14.1
M. B. F-26	SVC		11
	RA	5/-2	14.71
Art. sat.	LA	6/-2	19.25
88.4%	PV	7/2	19.65
	RV		14.41
	PA	62.5/35	14.14
R. S. F-41	SVC		13.06
	RA	7/3	16.06
Art. sat.	RV	80/4	
81%	PA	80/48	13.06

The compared catheterization studies of three patients demonstrated in Table I serve to emphasize this point. These three patients had essentially similar defects of the same size and location. The main variant was the duration of the defect as noted by their different ages. All three were surgically closed. As noted from this table, R. T., a boy aged 9, had a large shunt flow as shown by 3.4 volumes per cent difference in the oxygen content of the right auricle over the superior vena cava. As yet he had not developed any increased tension in the pulmonary artery or right side of the heart. Also, his blood was 99.1 per cent saturated. A defect of one and one-half inches was found in the center of the atrial septum, which was repaired. He is now entirely well. In contrast to this, M. B., a woman aged 26, also had a significant oxygen differential of 3.71 volumes, but this defect had persisted long enough to cause both pulmonary hypertension (62.5/35 mm. Hg) and arterial desaturation (88.4 volumes per cent). This patient was operated upon and the defect closed. Although this patient is improved she did not obtain the same degree of improvement as the boy mentioned previously. This point is further emphasized by the case of R. S., a woman aged 41. There was a significant oxygen differential in this patient of 3 volumes. The pulmonary artery pressure, however, was elevated to 80/48 mm. Hg and the arterial saturation was reduced to 81 volumes per cent. This patient was operated upon with closure of the septal defect, but she died three days postoperatively. Post-mortem examination of the lungs revealed extensive thrombosis of the right pulmonary artery. This was felt to be due to the increased tension and stasis of the pulmonary circulation. There was considerable mediosclerosis of the pulmonary vessels. The exact limits are not established as yet, but patients with pulmonary pressures over 75 and arterial saturations less than 85 volumes per cent probably should not

be operated upon because of the extent of the irreversible damage to the pulmonary circulation. Other factors, however, must also be taken into consideration. These are the age of the patient, the duration during which elevated pressures have existed, the size of the heart, the degree of pulmonary vascular changes, and the pulmonary reserve.

It is possible that after this degree of pulmonary sclerosis develops, the increased flow of blood and pressure to the lungs is necessary to maintain sufficient capillary filtration pressure for oxygenation. Catheterization studies in other patients have shown in several instances equalization of the right and left auricular pressures, or reversal of shunt flow. In one patient, a girl aged 13, repeat catheterization studies over one year's time showed the shunt flow to reverse itself as determined by the pressures within the right and left auricles. The arterial saturation also dropped from 92 to 79 volumes per cent. Obviously, such patients have advanced beyond the stage where surgical closure would be of any benefit.

Patients with uncomplicated atrial septal defects as single lesions rarely get into trouble before 5 years of age, at which time the defects can be safely repaired. This report deals with the surgical closure of atrial septal defects in fifteen patients who were not complicated by other congenital defects. The oldest was 49 years of age and the youngest 5 years. Three patients had an associated Lutembacher's syndrome. These patients had a commissurotomy for their mitral stenosis performed through the atrial septal opening prior to its closure. One patient had increased pulmonary pressure and reduced arterial saturation beyond the limits now considered safe for such closure. This was the second patient upon whom operation was performed, before the limits of pressure levels and arterial desaturation were established. This patient, R. S., a woman aged 41, was described previously in this paper. Her arterial saturation was only 81 volumes per cent and the pulmonary artery pressure was elevated to 80/48 mm. Hg. The failure of this patient to survive the operative procedure was due to the advanced stage of her disease. There were recent mural and older obturating thrombi of the pulmonary arteries as a result of the hypertension and stasis of the pulmonary circulation. This death was not due to any fault in the surgical technique employed. The fourteen remaining patients had what could be referred to as uncomplicated atrial septal defects, although three did have moderate degrees of mitral stenosis. In this group there were no deaths. All the operations were performed by variations of a closed technique, which will be described. In none of these patients did the possible complications inherent in other techniques occur, such as air embolism, ventricular fibrillation, cerebral and coronary anoxia, faults in a mechanical pump oxygenator, dislodgment of foreign bodies, or fibrosis of pericardial grafts, such as has occurred in other types of techniques employed by other authors. All these patients were improved by the operation. The degree of improvement was largely proportional to the duration of the defect and the degree of elevation of the pulmonary pressures.

It is impossible to reproduce defects in the atrial septum in the experimental animal similar to ones encountered in patients where essentially the

entire septum may be absent. Small ones made experimentally may be closed satisfactorily in a number of ways. Cohn[1] in 1947 closed small defects by invaginating the right auricular wall and fixing it to the defect by one or two sutures followed by severing the tip of the invaginated portion by means of a wire snare.

In 1948 Murray[2] described passing mattress sutures approximately in the plane of the atrial septum beginning at the site of the transverse sinus behind the aorta and coming out posteriorly between the superior vena cava and the right pulmonary veins. When these sutures were drawn taut, the anterior and posterior walls of the atrium were compressed together. Swan and his co-workers[3] described inversion of both the right and left auricular appendages into the septal opening and fixation of the appendages in this manner by plastic buttons. He has subsequently abandoned the procedure because the opening was not effectively closed and there was the danger of partially obstructing the orifices of the pulmonary veins. Bailey[4] in 1952 modified this technique by suturing the excess tissue of the right auricular wall into the septal defect by means of a purse-string suture directed by the intracardiac finger. This technique he referred to as an "atrio-septo-pexy."

Hufnagel and Gillespie[5] in 1951 reported the experimental use of double plastic disks or buttons in the closure of such defects. This appears to have little clinical application because of the thinness, irregularity, and absence of a rim. Martin and Essex[6] employed the use of sheets of polyethylene 1 to 2 cm. in diameter to successfully close experimentally produced defects.

Gross[7] in 1953 described the use of a rubber dam (atrial well) sutured to the right auricle through which he closed septal defects by means of plastic buttons, sheets of polyethylene, or direct suture. In three of his series of seven patients plastic buttons were used, which became dislodged, and the patients died. Death also occurred in the patient in whom a polyethylene sheet was used.

Dennis[8] in 1951 and Gibbon and his co-workers[9] in 1953 employed mechanical pump oxygenators both experimentally and in the clinical closure of atrial septal defects. The venae cavae were occluded during the procedure. The incidence of ventricular fibrillation and air embolism is high when such pump oxygenators are used. They have had one successful clinical case. Pump oxygenators so far have been too involved and associated with too many complications to be generally accepted. It is possible that with greater use of cross-circulation, as employed by Warden and co-workers,[10] the open method of surgical closure may become popular, but the danger of air embolism is always present.

Bailey[11] and Lewis[12] have closed atrial septal defects under direct vision by means of vena caval obstruction and hypothermia. Bailey has returned to the closed method because of the higher incidence of possible complications associated with the open method. One cannot safely operate over five minutes with the heart open without the possible danger of cerebral damage. Hypothermia in itself may be detrimental to the failing heart. Again, the incidence of air embolism is present.

Many of the advocates of the "open technique" criticize the "closed methods" on the basis that the defect cannot be visualized or that the defect may be too large to be closed by such methods. There is no question that it is easier to suture the defect with the heart opened rather than closed, but until such methods are as safe as closed techniques the latter should be preferred. Such defects can be closed just as effectively by closed methods, and it would be our opinion, even more so for the surgeon is not hurried and limited to the space of a few minutes to close a possible complicated defect.

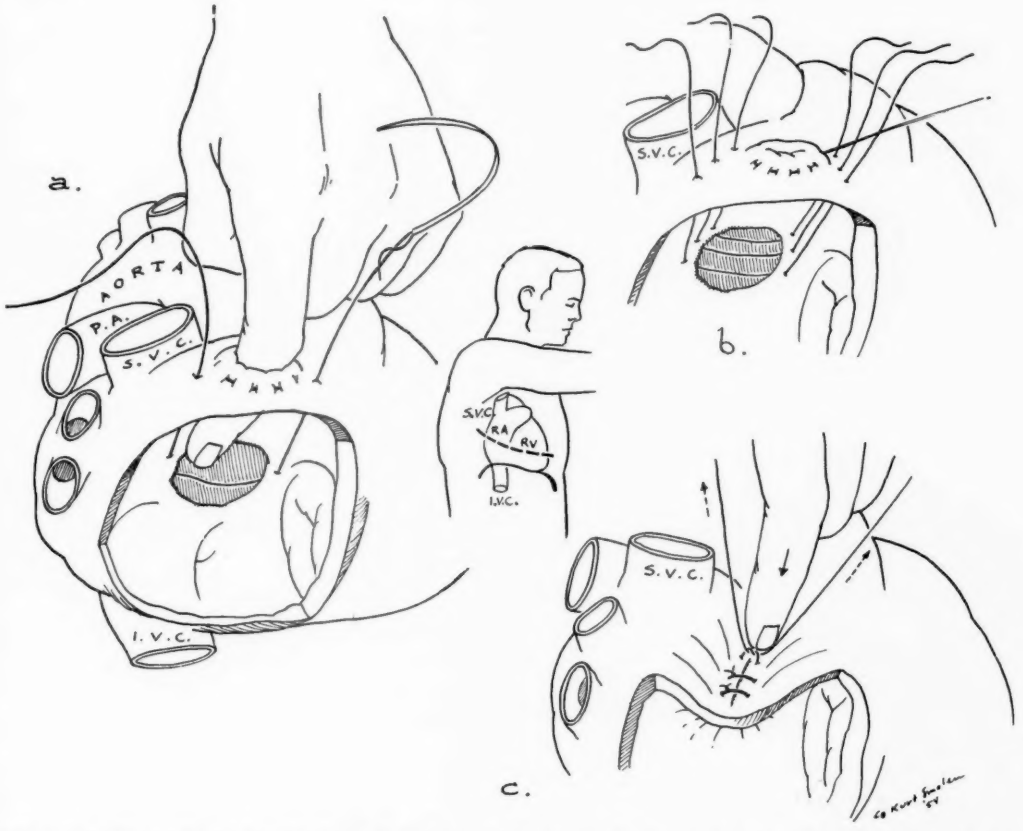


Fig. 1.—Diagrammatic illustration of technique employed in closure of atrial septal defects by invaginating excess atrial wall.

The technique evolved in the closure of atrial septal defects over the past several years will be described. As stated previously, there was only one death in fifteen patients operated upon, and in this instance the death was not attributable to any complications inherent in the operative procedure, such as air embolism, ventricular fibrillation, failure of proper functioning of a pump oxygenator, dislodgment of foreign bodies, and so forth, but rather due to a failing heart associated with irreversible damage to the pulmonary circulation caused by the existence of the condition over a long period of time. There have been no deaths in the last thirteen patients. The age of the patients in this group ranged from 5 to 49 years of age. The size of the defect ranged

from 2.5 cm. to complete absence of the septum. Two of these patients were closed by the technique of atrio-septo-pexy as described by Bailey.[4] Two additional patients were closed in a somewhat similar manner using individual sutures as demonstrated in Fig. 1, suturing the edges of the myotomy opening in the right auricle to the edges of the defect. One patient in whom there was

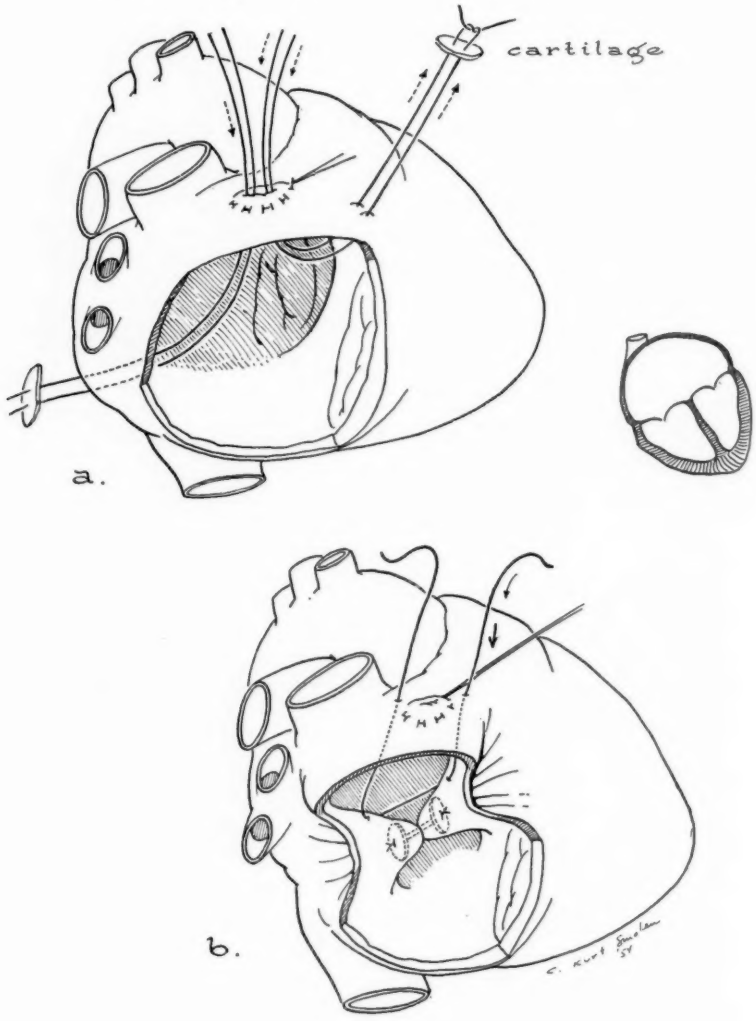


Fig. 2A.

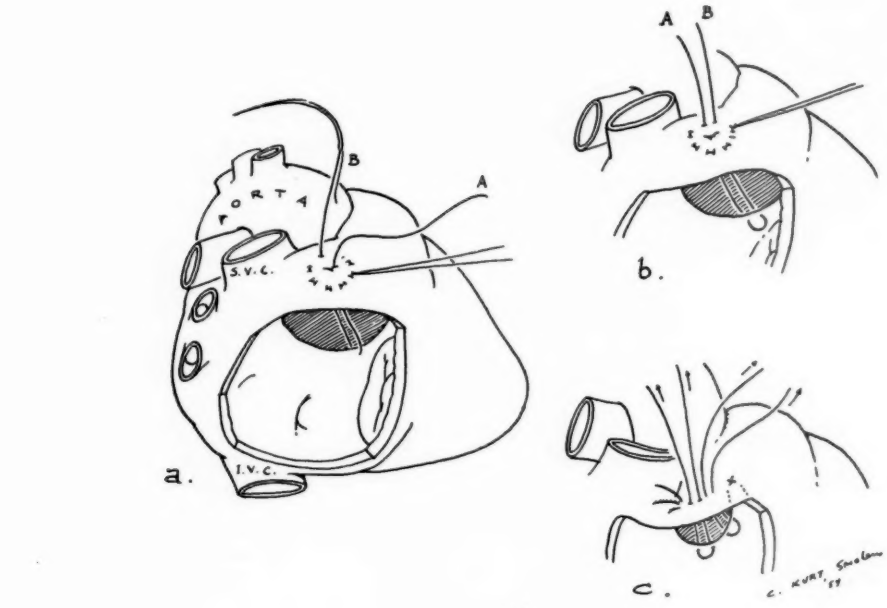
Fig. 2.—Diagrammatic sketch of technique employed in fashioning an atrial septum in a patient with a three-chambered heart (see text).

complete absence of the auricular septum, a woman aged 24, was treated by approximating the anterior and posterior walls of the common auricle by mattress sutures introduced by means of a large blunt needle through the myotomy opening and out anteriorly beneath the aorta. The other end of the suture was then threaded and passed in a similar manner (Fig. 2) through the posterior auricular wall and pericardium. Several sets of such sutures were so placed as mattress sutures. These were threaded over small sections of

cartilage anteriorly, drawn taut, and tied over pericardium posteriorly. This left a defect about one inch wide adjacent to the tricuspid–mitral valve septum. To occlude this space, the enlarged auricular appendage was invaginated adjacent to the septum and sutured posteriorly by passing mattress sutures through the appendage and out posteriorly at the anatomic site for a septum. The invaginated appendage was then sutured to the new septum cephaladly and the tissue between the tricuspid and mitral valves caudally, completely obliterating the defect.

Fig. 2B. *(For legend see opposite page.)*

The others have been closed by what is felt to be the most effective method. In anteriorly or posteriorly placed defects, mattress sutures are introduced through the myotomy opening by large blunt needles and out either anteriorly or posteriorly (Fig. 3), depending upon the position of the defect in the septal plane, drawn taut, and tied. Those defects located centrally either can incorporate small segments of auricular wall and be tied, or after the suture is



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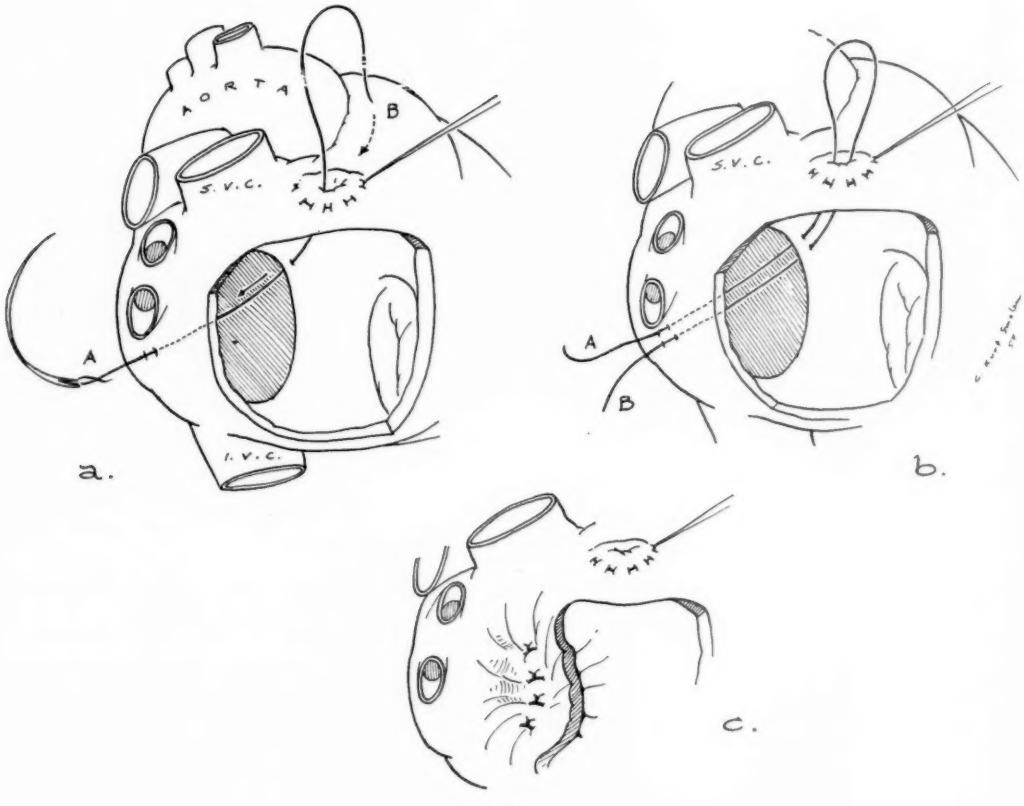

B.

Fig. 3.—Diagrammatic sketch of technique employed in closure of anteriorly or posteriorly placed septal defects.

so placed the ends can be obtained, withdrawn through the myotomy opening, and tied, pushing the knot through this opening. The sutures are cut by passing a thin pair of scissors through the myotomy opening or through a separate myotomy opening and guided by the intracardiac finger (Fig. 4).

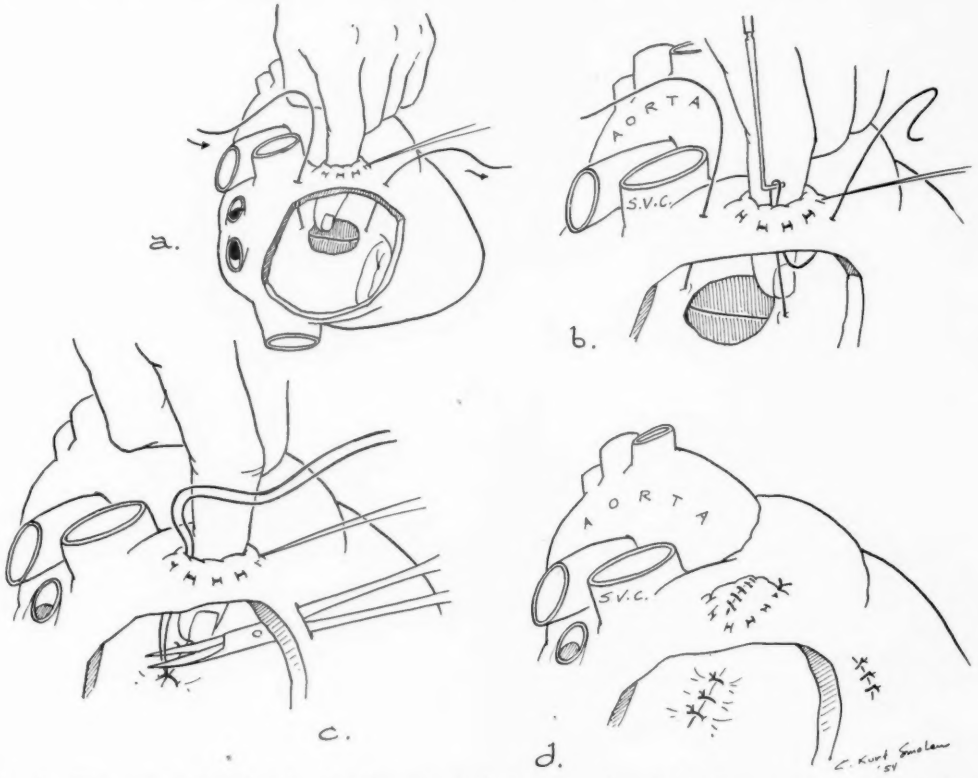

Fig. 4.—Diagrammatic sketch of alternate technique employed in closure of centrally placed septal defects.

SUMMARY

The altered cardiopulmonary dynamics secondary to atrial septal defects is discussed. The rationale for early surgical closure of such defects before irreversible damage to the pulmonary circulation develops is presented. Variations of closed techniques for closure of these defects are discussed.

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THE EFFECT OF VENOUS OCCLUSION ON PERIPHERAL BLOOD FLOW DURING ACUTE ARTERIAL INSUFFICIENCY

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SINCE Makins'[1] observations on acute arterial injury during the Boer War, each war has renewed interest in this problem. During the recent Korean hostilities, immediate repair of major arterial injuries drastically reduced the incidence of amputation.[2] Damage to soft tissues and collateral vessels often jeopardized the success of arterial repair in these limbs. The major venous channels were preserved, in so far as technically possible, on the assumption that venous occlusion was deleterious in the presence of arterial insufficiency.

The effect of venous occlusion on peripheral blood flow has been the subject of repeated discussion for many years. There has been particular disparity in opinion when this occlusion has been in association with arterial insufficiency. Clinical and laboratory observations have been reported suggesting a favorable effect with venous ligation in obliterative arterial disease as well as with arterial trauma.[3-17] Evidence has also been accumulated indicating a deleterious effect on flow in major arteries in the presence of concomitant vein ligation.[18-25] Of course, acute massive venous occlusion of the extremity has been known clinically to produce gangrene.[26]

Simeone and associates[23] reported a decrease in muscle efficiency when venous occlusion was superimposed upon arterial occlusion. Cullen and coworkers[31] noted no subsequent improvement in peripheral blood flow with concomitant venous ligation at the time of arterial occlusion as measured by disappearance of radioactive sodium from muscle in serial studies. However, peripheral flow measurements have not been made showing the acute effects of venous occlusion during arterial insufficiency.

The various enthusiastic clinical claims for intermittent venous occlusion are also related to this problem. This has been viewed as a method to improve peripheral circulation in the presence of arterial insufficiency.[29, 30] It is apparently believed that circulatory improvement should result from the reactive hyperemia that occurs as a release phenomenon. Thompson and Vane,[24, 25] using perfusion experiments, demonstrated that the flow debt incurred in the major arteries by venous occlusion is not overcome by the transient increase in flow observed upon release of the occlusion. Experimental data are not available showing the effect of intermittent venous occlusion on blood flow during periods of acute arterial occlusion.

Kety[32] originally described the method of measuring effective blood flow in muscle by following the disappearance rate of injected Na^{24}. It is accurate

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as an indicator of directional changes in blood flow, and within limitations is stated to be quantitative. He recorded the marked change in disappearance rate with arterial occlusion by tourniquet. Rapaport and associates[27] and McGirr[28] have shown a decrease in disappearance rate with venous occlusion alone.

The present study relates to the acute effect upon peripheral blood flow of venous ligation as well as intermittent venous occlusion during arterial insufficiency.

Method.—Healthy mongrel dogs weighing 10 to 20 kilograms were anesthetized with Nembutal and the airway maintained with endotracheal intubation. The common carotid artery was cannulated and continuous blood pressure levels recorded. Venous pressure measurements were made via polyethylene tubing threaded into a peripheral vein of the extremity under study.

The blood supply to the extremities was prepared by isolation of the common iliac artery and vein bilaterally. The large sacral artery at the aortic trifurcation, as well as the hypogastric veins bilaterally, was ligated in the hope of reducing collateral channels and bringing circulation to and from the limb under more complete control.

Vessel occlusion was accomplished by accurately placed rubber-shod clamps, and tourniquet occlusion with a pneumatic tourniquet wrapped around the thigh.

Ten to fifteen microcuries of Na^{24}, in 0.1 c.c. isotonic saline solution (adjusted to pH 7.0), was injected into the gastrocnemius muscle and its disappearance rate followed with a Geiger-Müller counter. A direct writing graphic recorder charted the disappearance rate, which was taken as an indication of peripheral blood flow. These data were plotted against time on semilogarithmic graph paper after correcting all values for background. Final background readings were reached in one to two hours after the completion of the major portion of the experiment.

Mean arterial blood pressure was not altered by any of the vessel occlusions. Venous pressure showed its greatest elevation with venous occlusion alone, values of 400 to 500 mm. saline solution being reached. Arterial occlusion prior to venous occlusion resulted in only slight elevation, while simultaneous arterial and venous occlusion gave average increases in venous pressure of 200 to 300 mm. saline solution.

Each lower extremity was used on only one occasion and during the experiment was secured so that the counter and extremity bore a constant relationship to each other. Two to eight separate experiments were performed for each variation in technique described, and a summary of the resulting graphs follows.

Results.—1. *Normal:* Charting disappearance rate from the gastrocnemius muscle, without vessel occlusion, produced a straight-line graph for the first twenty to thirty minutes, the slope then decreasing slightly. Fig. 1 is a typical example and indicates the effectiveness of normal peripheral flow.

2. *Arterial occlusion alone:* Common iliac artery occlusion resulted in a marked decrease in the disappearance of the radioactive sodium, with the

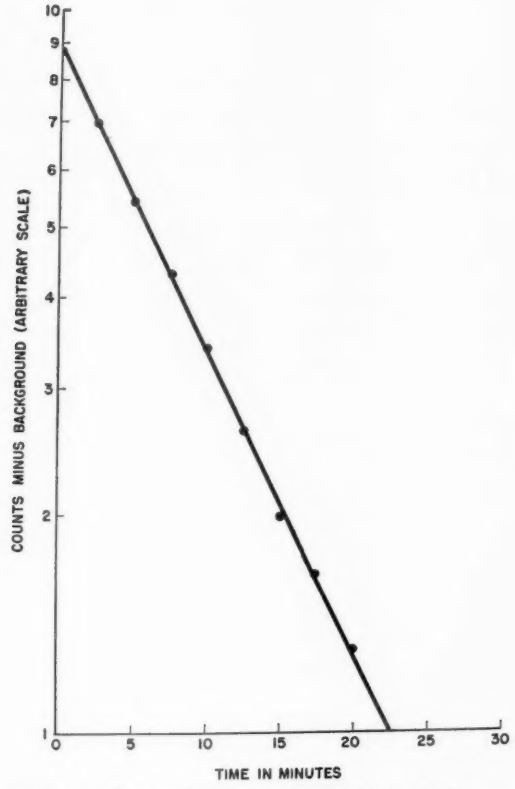

Fig. 1.—Example: Disappearance rate of Na^{24} (gastrocnemius muscle).

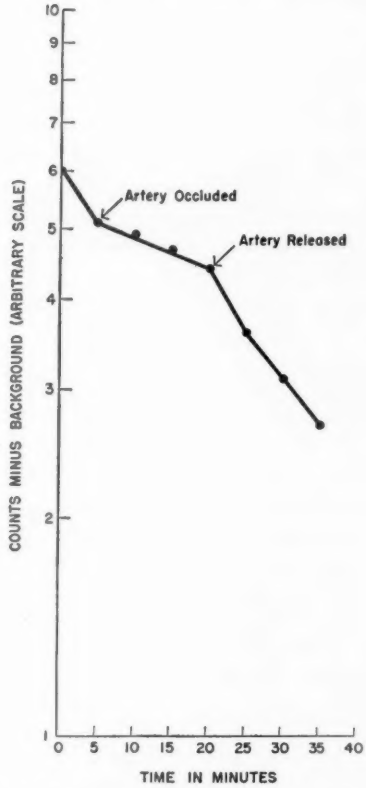

Fig. 2.—Effect of common iliac artery occlusion on disappearance rate of Na^{24} (gastrocnemius muscle).

establishment of a new slope which regained its normal appearance following release of the artery (Fig. 2). The degree of slowing varied somewhat in different animals, but varying the periods of arterial occlusion did not alter the general configuration of the flow graphs.

3. *Venous occlusion alone:* Occlusion of the common iliac vein always produced some slowing in the disappearance rate of Na^{24}. This was similar to, but not as marked as, arterial occlusion effects. The immediate result of release seemed to be an increase in flow, but the over-all disappearance rate can be seen to be no greater than normal (Fig. 3).

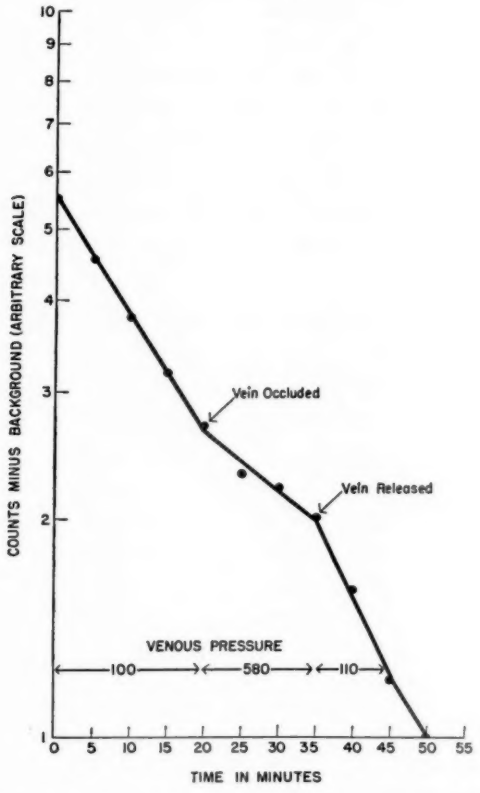

Fig. 3.—Effect of occlusion of common iliac vein on disappearance rate of Na^{24} (gastrocnemius muscle).

4. *Venous occlusion in the presence of arterial occlusion:* Occluding the common iliac vein after a preliminary ten-minute occlusion of the artery caused a further decrease in peripheral flow. This decrease occurred in all experiments, but was more marked in some than in others. Variance in the time intervals of the occlusion did not alter the trend and this was reproducible in each of the various combinations. Release of venous occlusion, while maintaining the original arterial occlusion, always resulted in an increase in peripheral flow. The slope of the graph was never greater than that recorded during the preliminary arterial occlusion. These findings were confirmed in eight experiments, Figs. 4 and 5 showing typical examples.

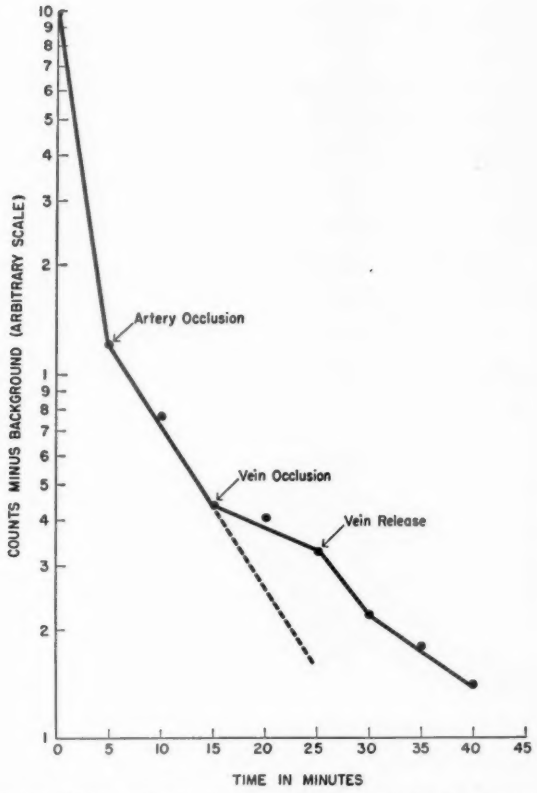

Fig. 4.—Effect of common iliac vein occlusion during period of common iliac artery occlusion on disappearance rate of Na^{24} (gastrocnemius muscle).

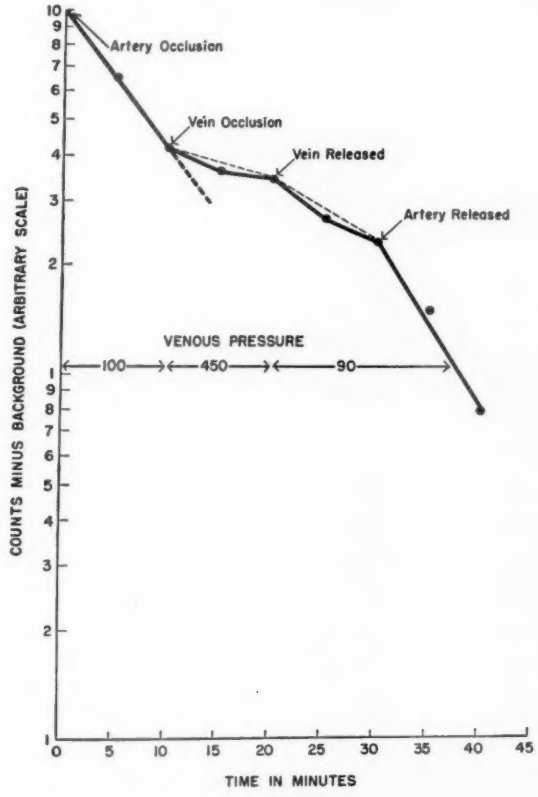

Fig. 5.

Release of arterial occlusion then caused the disappearance rate to approach its normal pattern. Injection of Na^{24} at later periods in the occlusion routine demonstrated the same release phenomena as in the other experiments.

Simultaneous occlusion of artery and vein caused the greatest decrease in disappearance rate. Release of either artery or vein improved the disappearance rate in all instances, and release of the second vessel, be it artery or vein, gave still greater improvement (Fig. 6).

The experiment of venous occlusion in the presence of arterial occlusion was repeated with subcutaneous injection of the radioactive isotope and the same results were obtained.

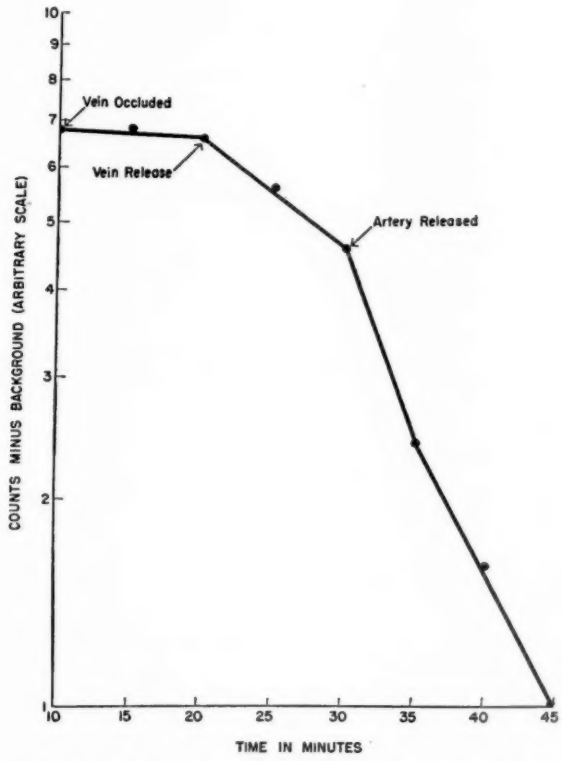

Fig. 6.—Effect of release of occlusion of common iliac vessels on disappearance rate of Na^{24} (gastrocnemius muscle). Common iliac artery occluded ten minutes before record.

5. *Tourniquet venous occlusion:* Venous compression in the presence of common iliac artery occlusion was produced by means of a broad pneumatic tourniquet around the thigh. It was found that 40 mm. Hg resulted in venous pressure rises comparable to those obtained with the previous iliac vein occlusions. Tourniquet pressures of 50 to 60 mm. Hg produced higher venous pressures than with simple major vein occlusion.

Experiments carried out with tourniquet pressures at each of these levels produced a decrease in Na^{24} disappearance rate comparable to that occurring with simple vein occlusion in the presence of arterial occlusion. Tourniquet release gave an increase in disappearance rate, but again, the net result was a

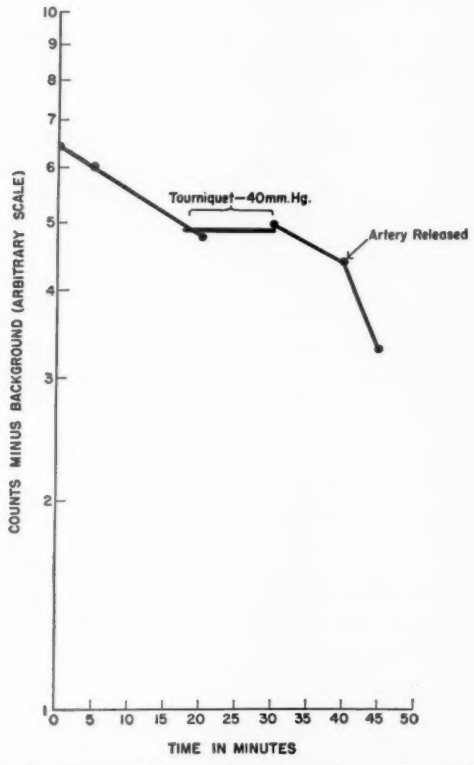

Fig. 7.—Effect of tourniquet compression on disappearance rate of Na^{24} during common iliac artery occlusion (gastrocnemius muscle).

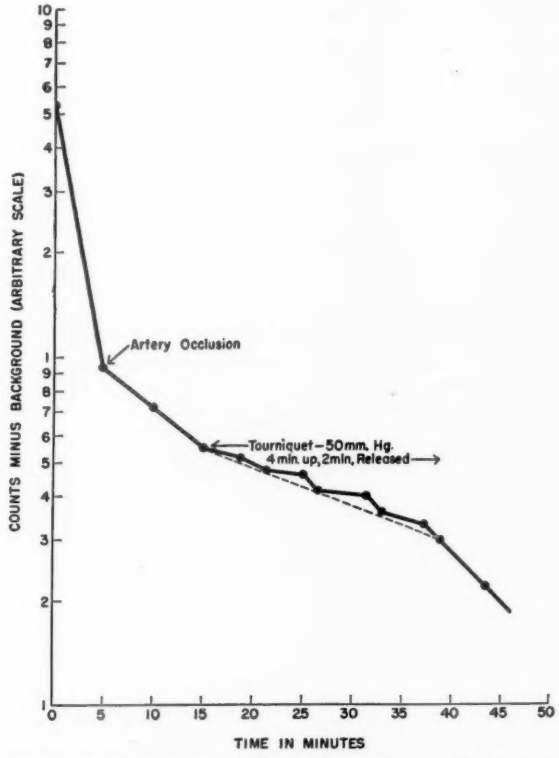

Fig. 8.—Effect of intermittent venous compression by tourniquet on disappearance of Na^{24} during common iliac artery occlusion (gastrocnemius muscle).

total decrease in flow, rather than an over-all net gain. Thus, even though a higher venous pressure was obtained, the result mimics that of iliac vein occlusion alone (Fig. 7).

This experiment was repeated with alternate occlusion and release of the tourniquet using a pressure of 50 mm. Hg and an arbitrary time schedule of four minutes' occlusion and two minutes' release. This was continued over a twenty-four-minute period, and in each instance an over-all slowing of the disappearance rate was demonstrated (Fig. 8).

Discussion.—With the varied conditions of this experiment, venous occlusion resulted in a decreased effective peripheral blood flow in muscle and subcutaneous tissue. This occurred in the presence of either an intact or occluded arterial flow. This decrease was not overcome by the transient increase in flow resulting from a later release of venous occlusion. This would seem to indicate that venous ligation produces only a deleterious effect upon the peripheral circulation in the crucial early period following acute arterial occlusion.

The contention that intermittent venous occlusion and release improve the circulation during acute arterial insufficiency also seems to have no logical basis. The transient increase in flow occurring with the tourniquet release did not compensate for the decrease incurred during the tourniquet compression.

Conclusion.—In the presence of common iliac artery occlusion in the dog, both common iliac venous occlusion and intermittent tourniquet occlusion decreased the effective peripheral blood flow as measured by the disappearance rate of locally injected Na^{24}.

We are grateful to H. Thomas Randall, M.D., and Leon Hellman, M.D., for their assistance, advice, and encouragement.

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THE EFFECT OF INDUCED PERIAORTIC INFECTION ON THE POTENTIAL DIFFERENCE MEASURED ACROSS THE AORTIC WALL

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IN SEVERAL long-term experiments to determine the potential difference (P.D.) across the wall of the healing graft and recipient aortic wall, it was noted that clinical evidences of toxicity, or infection in the experimental animal, were often accompanied by an increased P.D. usually of normal polarity.[1] In the instances when the P.D. reversed, so that the intimal electrode became positive, thrombosis often occurred.[1]

The present series of experiments was undertaken in an attempt to reproduce these phenomena, and determine whether induced periaortic infection might increase the measured P.D. It also seemed of interest to determine if a reversal of the normal P.D. might follow induced periaortic bacterial contamination and whether or not this reversal of polarity was accompanied by concomitant aortic thrombosis as had previously occurred.

MATERIALS AND METHOD

Seventeen normal mongrel dogs anesthetized during the initial operation with intravenous pentobarbital sodium were used. A single pair of polyethylene catheter electrodes (PE-100) were implanted across the lower abdominal aortic wall through a transperitoneal, transabdominal approach. After minimal dissection, the inner electrode was inserted through the inferior mesenteric artery into the aortic blood stream. The second electrode was attached to the adventitia of the aorta by multiple fine silk sutures. The catheters were then exteriorized through the dog's left flank.[1] The two major differences between these and the previous long-term experiments were the minimal use of dissection and the implantation of a single pair of electrodes across the aortic wall rather than implanting a graft with two pairs of electrodes. In order to make P.D. determinations, the electrode catheters were attached to a Leeds and Northrup null point slide wire potentiometer or Millivac* vacuum tube voltmeter through identical calomel half cells as previously illustrated.[1] The animals quickly became conditioned to the daily measurements, and lay quietly during the procedure. It was necessary to obtain a steady state potential since it was possible to measure action potentials through the circuit under the conditions of the experiment.

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*Millivac 17B Vacuum Tube Voltmeter. Produced by Millivac Instrument Corp.

An initial measurement was made following the operative implantation of the catheter electrodes while the dog was still anesthetized. The catheters were then buried beneath a heavy bandage and muslin binder. P.D. determinations were conducted daily until the initial healing peak had subsided (Fig. 1) and

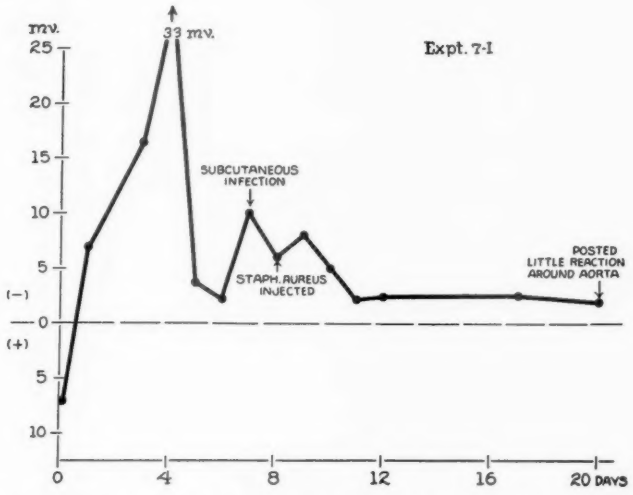

Fig. 1.—Illustration of a P.D. experiment in which the initial healing peak is very high with the intima negative. This is thought to be a normal typical response. The subsequent response to injected bacteria on day eight was very small in this experiment.

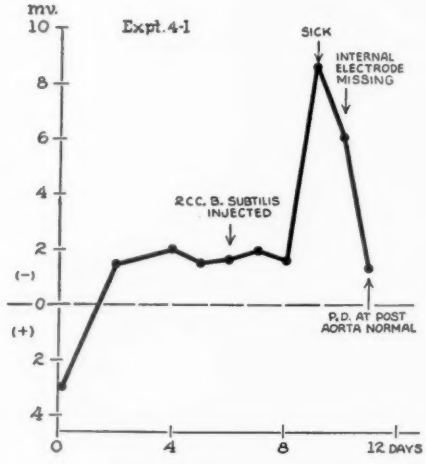

Fig. 2.—Illustrating a typical response of the P.D. across the arterial wall to the injection of bacteria into the periaortic tissues. As can be seen, the initial healing peak in this case never reached high levels. The initial P.D. after the introduction of the electrodes indicated sufficient injury had taken place to reverse the normal arterial P.D. for one day prior to revision to normal P.D. This happened in many of the experiments in which catheters were implanted.

the P.D. had approached a stable base-line level with the intima negative to the adventitia in the range of 1 to 2 mv. After low P.D. readings had been recorded for a few days an attempt was made to introduce 1 to 4 c.c. of a pure broth culture of vegetative strains of *Bacillus subtilis*, hemolytic Streptococcus, or

TABLE I

EXPT. NO.	OPERATIVE RESULTS	INITIAL P.D. POSTOP.	MAXIMUM HEALING PEAK P.D.	EFFECT OF BACTERIAL CONTAMINATION	SUBSEQUENT COURSE	AUTOPSY
1	Trouble canulating inf. mesenteric. Bleeding	−2.5 mv	−4.0 mv	Neg. peak, 10.5 mv followed by reversal of P.D.	Returned to normal polarity	Inflammatory mass surrounded aorta, few small intimal thrombi
2	Catheters implanted without event	−1.5	Persistently pos. 6 mv	Persistent reversal of P.D. to +6 mv	Markedly toxic. Positive P.D. persisted	Huge periaortic inflam. mass. Grade II mural thrombi present
3	Catheters implanted without event	+6.0	Quickly negative −2 mv	(+) 2 mv at bact. injection	None—avulsed electrodes	Not thrombosed. Normal aorta and periaortic tissue
4	Catheters inserted without event	+3.0	−2.0 mv	Rise in P.D. from −2 to −8 mv	Toxic 1 day later. Recovered	No occlusion. Periaortic connective tissue hyperplasia with inflam. mass
5	Catheters inserted without event	−1.8	+1.0 mv gradually (+)	None	None—avulsed electrodes	Aneurysmal mass with complete aortic occlusion
6	Catheters inserted without event	+0.5	−2.2 next day	Neg. peak to (−) 6.0 mv	Additional peak at 12 day (−) 2.5 mv	Area of inflam. discolored tissue with loops of bowel bound down in mass. Aorta free of thrombosis
7	Much trouble inserting electrodes	+7.0	−33 mv	Neg. very little response to bacteria	Normal course	Very little periaortic response. Plug still in catheter. Not successfully contaminated
8	Operation without event	−1.5 mv	−11.5	Reversal of P.D. in 3 days +15	Sick, hind-quarter weakness	Aorta completely occluded, below electrode. Purulent abscess around aorta in this area
9	Difficulty, bleeding and inserting electrodes	+1.5 mv	−1.0 mv	Neg. peak to −7.0 mv	Normal P.D. fell to 1.0 mv	No periaortic inflam. response. Grade II thrombus around catheter, R.I.
10	Difficulty inserting electrode cath.	+0.3 mv	−7 mv immediate	Small neg. peak −4.0 mv	Normal	Posted. No evidence of periaortic inflam.
11	Operation without event	−0.5	−3.0 mv	Initial neg. peak −5 mv	Reversal of P.D. to +15 +20 mv	Died with hind-quart. weakness and overwhelming infec. Trifurcation appar. completely occluded
12	Bleeding during operation	−0.5 mv	High neg. peak to 40 mv	High neg. peak to −30 mv. Fell toward normal	Repeat bacterial count peak to −10 mv	Small thrombi around catheter and attached loop wall. Periaortic infl. tissue present
13	Trouble inserting internal catheter	−8.8 mv	Large neg. spike, 55 mv	(+) peak for 1 day after bact. injected	Reverted to (−) intimal P.D. normal, flat	Normal. Little evidence of periaortic inflammation
14	Operation without event	−6.3	+2.5 mv quickly to 1.5 mv	None—catheters avulsed	Catheters avulsed	Much periaortic inflammatory response with Grade II aortic mural thrombosis
15	Trouble inserting catheter electrode. Bleeding	+43 large persistent (+) P.D.	−10 mv	−10 mv. intimal (−) from (+) base line	Uneven. Dog sick	Grade II aortic throm. extending down and occl. both R. common iliac and hypogastric
16	Considerable peritoneal bleeding	+21	−2.0 mv max. from (+)	(+) peak 4 days later	Persistent (+)	Small amt. periaortic inflam. tissue. Grade III thrombi
17	Operation without event	−70 mv	−70 mv	None	Flat, approx. 2-5 mv	Control

strain P78 of hemolytic *Staphylococcus albus** in concentrations of $1 \times 10^{8-9}$/c.c. through the external catheter. The P.D. measurements were continued until the dog died, the electrodes were avulsed, or the animal completely recovered without further complications for a considerable period of time.

The precontamination base line in each experiment afforded a control level for the further determinations. Thus, each animal acted as his own control.

RESULTS

(Table I.) The number of dogs which developed some degree of aortic occlusion in the experiments was unexpectedly large. The thrombi were classified according to the technique previously developed,[5] a zero indicating no thrombosis, the increasing number indicating a progressive degree of thrombosis. A Grade IV thrombosis completely occluded the vessel lumen.

TABLE II

REVERSAL OF POTENTIAL (48+ HR.) ↓	NUMBER OF DOGS ↓	NUMBER OF THROMBOSES (GRADES II-IV) ↓	REMARKS
No reversal—	10	1	2 not adequately infected
Primary reversal—	5	5	2 reversed before introduction of periaortic bacteria
Secondary reversal—	2	1	
	17 dogs used in the experiment		

A total of seventeen experimental animals were used in these experiments. Of these, fourteen had electrodes in place for prolonged periods greater than two weeks. Two of the dogs developed a reversal of P.D., became extremely ill, and died soon after the electrodes were implanted. Both of these dogs were found to have aortic thrombi at autopsy. One of the seventeen never had bacteria injected into the periaortic area, but served only as a long-term control.

Two at necropsy gave no evidence of tissue response to massive local contamination. The cotton plugs routinely placed in the external catheter, RO, to keep out air bubbles were still tightly in place. It must be assumed that bacteria were never successfully injected into these dogs.

Eight of the remaining eleven dogs developed a P.D. peak of normal polarity, greater than four times the base-line value following the introduction of bacteria into the periaortic area, and displayed massive local connective tissue hyperplasia at necropsy.

Seven of the total of seventeen dogs, including the two previously mentioned, displayed a prolonged reversal of P.D., two of them before, and five of them after, the injection of bacteria. Of these seven, six had a Grade II or greater

*Provided through the courtesy of Mr. Frank Kapral, Dept. of Microbiology.

occlusion at autopsy, four of them having a complete vascular thrombosis. The remaining dog (No. 1) that did reverse its P.D. for a two-day period displayed only small mural thrombi.

One dog (No. 9), not of the seven, had a small Grade II thrombus around the catheter at autopsy, never having displayed a reversal of P.D. None of the other dogs showed any aortic thrombosis.

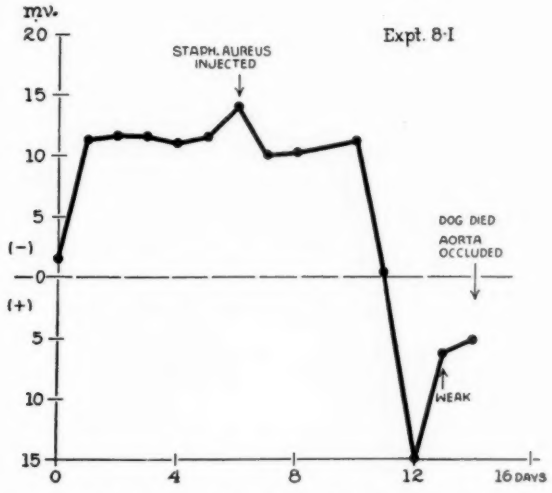

Fig. 3.—In this experiment the initial P.D. response to bacteria was a reversal of potentials. The aorta subsequently completely occluded.

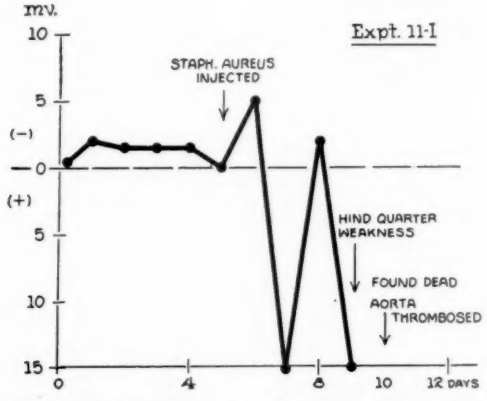

Fig. 4.—Here the initial P.D. response to bacteria was a typical average response. Subsequently the P.D. reversed polarity and the dog developed hind-quarter paralysis. At autopsy the lower abdominal aorta was completely occluded.

DISCUSSION

While action potentials due to dog movement and respiration during the determinations may have contributed to the final measured P.D., it appears that the potentials measured in these experiments are of the correct order of magnitude. It is doubtful that they are entirely artifact.

Air bubbles in the catheter electrodes have been considered and have been found to change the measured P.D. relatively little, ± 2 to 3 mv, if they occupied lengths of catheters up to 10 cm.

The catheter introduced into the blood stream of the aorta must be considered in the light of its activity as a foreign body. It would not seem to be the sole factor in the etiology of the intravascular thrombosis in these experiments since this occurred in only seven of the seventeen experiments and then only after a fairly long time interval. There were no sudden complete aortic occlusions subsequent to the introduction of the catheter.

While we feel that they are not conclusive, these experiments seem to offer confirmatory evidence supporting the contention that either a generalized toxicity due to infection, or a local inflammatory response to massive bacterial contamination, may result in an increase in the P.D. measured across the aortic wall. Usually the increased P.D. has a normal polarity with the intima negative to an externally placed electrode. If the P.D. polarity reverses for a two- or three-day period, it usually signifies an extensive change in local conditions. It is often accompanied by, and in fact may be, a contributory factor in the ensuing thrombus formation.

If, during the initial operation, considerable intraperitoneal bleeding occurs and extensive dissection must be performed, one has the impression in this small series that the initial expected postoperative "healing" P.D. peak (as it has been named) is both higher and more prolonged. One possible explanation of the phenomenon is that it may be a manifestation of peritonitis.

Calculations from the intial papers of this series[1] indicate that the larger part of the P.D. measured by this technique is created by the periaortic tissues rather than by the aortic wall itself. This being true, a major change in P.D. must be assumed to be due to the periaortic tissues becoming more positive as the usual response to injury. Usually there is a reversal of this polarity only in the peculiar case when vascular occlusion of some magnitude takes place. The physical biochemistry of this phenomenon has not yet been elucidated. However, several recently completed experiments help throw some light on the characteristics of the process.[2-5]

In 1924, Abramson[6, 7] advanced the theory of electrotaxis to explain the diapedesis of white cells into an area of tissue inflammation or injury. The results of these experiments in general seem compatible with that theory. Proving that white cells emigrate to the area of tissue injury because of injury potentials will be considerably more difficult but perhaps worth while.

SUMMARY

Massive local contamination of the tissues around a segment of aortic wall across which P.D.-measuring electrodes have been previously placed resulted in a normally oriented P.D. peak in the majority of the experimental animals.

In others it resulted in either a primary or secondary reversal of P.D. This condition was accompanied by intravascular thrombosis in six of the seven animals in which it occurred in these experiments.

The results are discussed.

Acknowledgments.—We wish to thank Dr. I. S. Raydin and Dr. J. E. Rhoads for their help in making this research possible, and Mrs. Jonell Mayers for her many hours of hard work on the project.

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THE PHYSIOLOGIC AND PATHOLOGIC EVALUATION OF THE IMPLANTATION OF THE INTERNAL MAMMARY ARTERY INTO THE LEFT VENTRICULAR MYOCARDIUM FOR THE TREATMENT OF CORONARY ARTERY DISEASE

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MYOCARDIAL ischemia, secondary to occlusive arteriosclerotic coronary artery disease, continues to pose a therapeutic problem. Coronary artery heart disease constitutes 75 per cent of all diseases of the heart[1] and remains the major factor in the mortality rate of 35- to 65-year-old men.[2]

In recent years, we have been stimulated by this problem and have attempted to evaluate the various surgical procedures designed to increase the intercoronary anastomoses on a physiologic basis.

To date, attempts to augment an impaired coronary arterial circulation have centered about three general types of procedures: (1) the development of adhesions between the ventricle and other structures, mainly the pericardium, as reported by Thompson, and the omentum, as reported by O'Shaughnessey; (2) arterialization of the coronary sinus in an attempt to retroperfuse the ischemic myocardium, as described by Beck and his associates; and (3) the implantation of a systemic artery into the left ventricular myocardium, as described by Vineberg and his co-workers.

During previous investigation of the coronary circulation,[12] we have developed a simple and effective means of evaluating the contribution to the collateral coronary arterial circulation made by the various cardiac procedures. When a coronary artery is ligated and transected in the normal dog, a steady retrograde flow of blood is obtained from the peripheral segment of the divided artery. Independently, Gregg and his associates[18] and Eckstein and Leighninger[19] utilized this same method. In all instances, the oxygen content of this backflow blood approximates that of a concomitantly drawn aortic sample. Since the blood from the peripheral segment of the ligated coronary artery is arterial in nature, and since the flow is continuous, it must arise from the neighboring coronary arteries and, therefore, represent flow through the interarterial coronary collaterals. Thus, by quantitating the retrograde coronary arterial flow, a simple, if rough, means of measuring and comparing increments of change in the interarterial collateral flow may be evolved. In previous experiments upon normal

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animals, upon animals which have had nondescript cardiac procedures performed,[12] and upon a group with arterialization of the coronary sinus,[13-15] we have found this method of evaluation to be simple and adequate.

We have been interested in the technique of implanting the internal mammary artery within the thickness of the left ventricular myocardium, as conceived and described by Vineberg and his co-workers. These workers have reported the development of a collateral circulation between the implanted internal mammary and the left anterior descending coronary arteries.

Little seems to be known of the exact physiologic changes which occur in the coronary circulation following the Vineberg procedure. Since we previously had succeeded in evaluating increments of change produced in the intercoronary arterial collateral flow by other cardiac procedures,[13-15] we have studied the Vineberg operation in an effort to determine whether there might be an increase of extracoronary collateral flow which could be attributable to the implanted internal mammary artery. This, then, would provide a quantitative basis for comparing this procedure with others designed to stimulate extracoronary anastomoses, and perhaps with those designed to increase the intercoronary collateral system.

METHOD

Mongrel dogs, whose weights varied from 15 to 18 kilograms, were used for the performance of left internal mammary ventricular transplant. They were anesthetized with intravenous pentobarbital sodium, after which artificial respiration was maintained with intermittent positive pressure supplied through an endotracheal tube with an inflated rubber cuff.

The left chest was entered through the fifth intercostal space, and 10 c.c. of procaine hydrochloride (2 per cent) was injected into the pericardial sac. The left internal mammary artery was dissected from the chest wall for a variable distance, using a meticulous technique, great care being taken not to traumatize the vessel. The artery was dissected from the sixth to either the fourth or third intercostal space. The extent of the dissection depended upon the angulation of the vessel when brought to the left ventricle at the point selected for the production of the tunnel. We preferred to limit the dissection to the fourth intercostal space. However, if it appeared that the artery then would be kinked when transplanted, the dissection was carried to the third intercostal space. The intercostal vessels were all doubly ligated and transected between the pairs of ligatures. A 2 mm. segment of the sixth intercostal vessel was carefully maintained intact. The distal end of the internal mammary artery was doubly ligated and transected between the ligatures. The pericardium was opened, and a tunnel was prepared in the anterior wall of the left ventricle, using a fine-curved mosquito hemostat (Fig. 1). The vessel was pulled into the tunnel, where it was fixed by suturing the terminal ligature to the epicardium (Fig. 2). Immediately prior to transplanting the vessel into the tunnel, the ligature on the 2 mm. segment of the sixth intercostal vessel was amputated so that 1 mm. of the vessel remained, from which bleeding occurred freely in pulsatile fashion. No attempt

was made to control bleeding from this open intercostal vessel, which was then pulled into the myocardial tunnel. The pericardium was partially closed to prevent herniation of the heart from the sac, care being taken to keep it from impinging upon the implanted artery. The chest was closed in routine fashion, and the animal was treated with 300,000 units of procaine penicillin daily for three days. After the first postoperative week, the animals were transferred to the veterinarian's kennels for six months. Then they were returned for physiologic study.

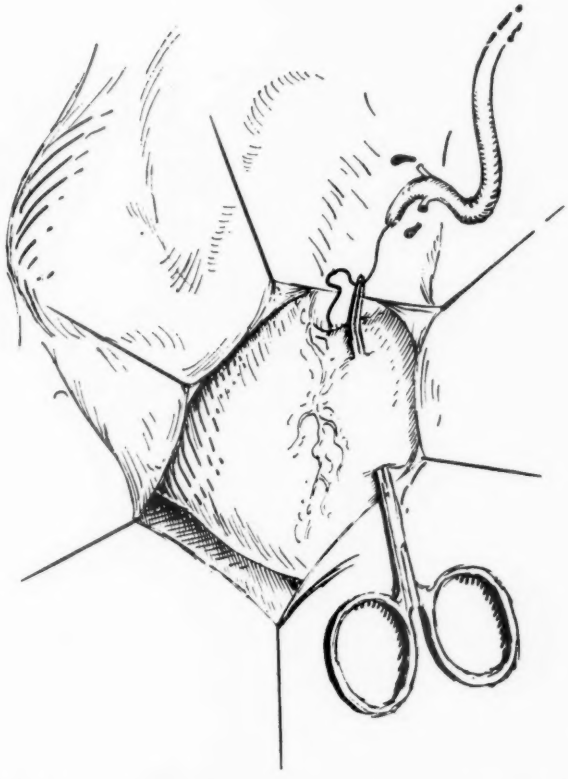

Fig. 1.—The internal mammary artery has been dissected from the thoracic wall from the sixth to the fourth intercostal space. The distal portion of the vessel has been doubly ligated and transected between ligatures. The transmyocardial tunnel is being prepared.

The left chest was opened through the fourth intercostal space, and all pleuropulmonary adhesions were freed. The pericardium was opened, and with the aid of a needle-tipped polythene catheter connected to a water manometer, the coronary sinus was cannulated and the mean sinus pressure was obtained. A specimen of coronary sinus blood was drawn. The left anterior descending coronary artery was isolated, and ligated at its origin. An incision was made in the artery just distal to the ligature. Through it the distal segment of the artery was cannulated. Simultaneous blood samples were taken from the pulmonary artery, the aorta, and the distal segment of the ligated anterior descending artery. The oxygen content of all blood samples was determined; oxygen capac-

ity and saturation were determined in the aortic sample. Next the cannulated vessel was attached to a water manometer, and the peripheral coronary arterial pressure was recorded.

The minute volume of retrograde blood flow from the cut end of the distal portion of the anterior descending artery was secured. In an effort to determine whether the source of this retrograde blood flow was the unoccluded circumflex branch of the left coronary artery by way of the intercoronary collateral vessels, or the implanted internal mammary, the following experiment was performed.

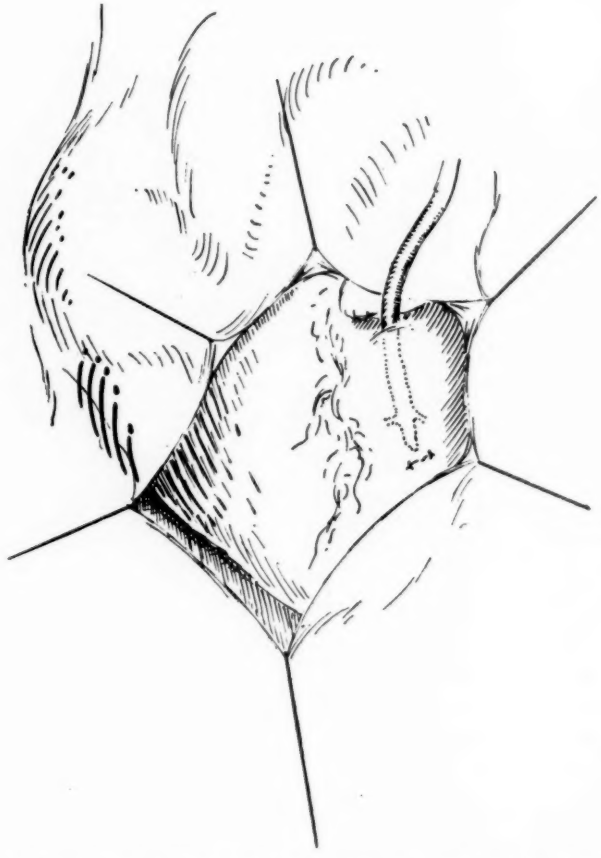

Fig. 2.—The vessel has been implanted into the anterior wall of the left ventricle, and has been fixed by sutures to the epicardium at the distal portion of the tunnel.

First, the implanted artery was occluded proximal to its entrance into the myocardial tunnel, and the minute volume of retrograde blood flow from the peripheral segment of the anterior descending artery was noted. Next, the circumflex branch of the left coronary artery was occluded at its origin, and the change in the retrograde blood flow from the distal end of the anterior descending artery was again noted.

Upon termination of these physiologic experiments, the heart and implanted internal mammary artery were removed carefully and fixed in formalin for pathologic examination.

RESULTS

Retrograde Blood Flow From the Peripheral Segment of the Ligated and Transected Anterior Descending Branch of the Left Coronary Artery.—The results are shown in Table II. Retrograde bleeding from the distal segment of the ligated anterior descending artery ranged from 0.5 to 5.0 c.c., with an average of 2.3 c.c. per minute. When the left internal mammary arterial implant was occluded proximal to its entrance into the myocardial tunnel, the backflow from the peripheral segment of the ligated anterior descending artery again ranged from 0.5 to 5.0 c.c., with an average of 2.2 c.c. per minute.

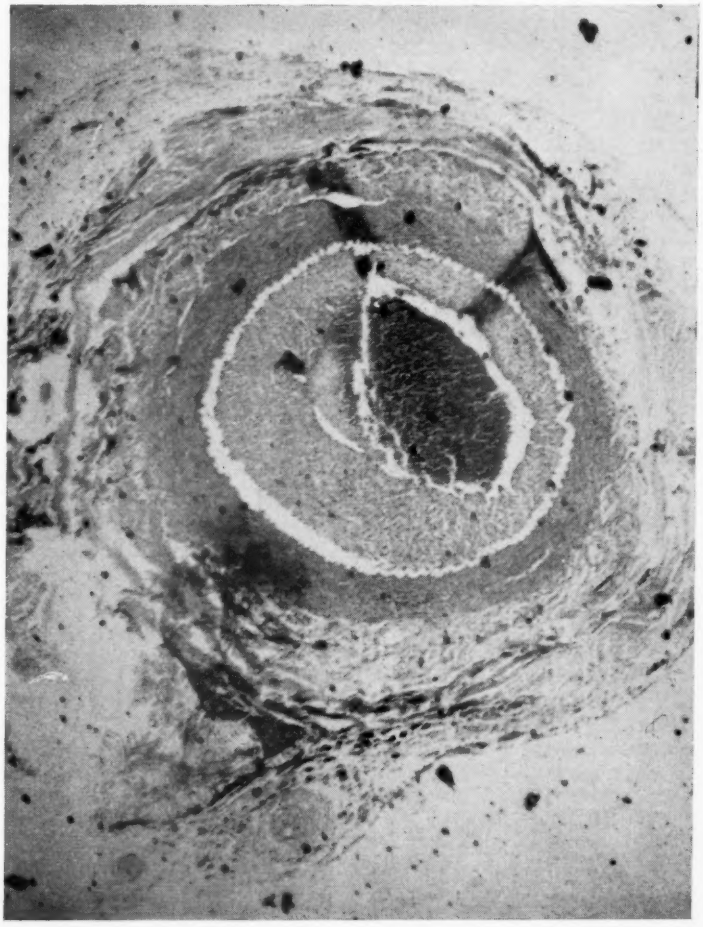

Fig. 3.—(Dog No. 1269). This is a section of the internal mammary arterial transplant just at its entrance into the myocardial tunnel. There is a 50 per cent reduction of its lumen due to intimal hyperplasia. The lumen is patent, and contains post-mortem clot. Hematoxylin and eosin (×26; reduced ¼).

The clamp was removed from the internal mammary implant, and the left circumflex coronary artery was occluded at its origin. The retrograde blood flow from the distal segment of the ligated anterior descending artery now ranged from 0.0 c.c. to 1.6 c.c. with an average of 0.8 c.c. per minute.

TABLE I. RETROGRADE LEFT ANTERIOR DESCENDING CORONARY ARTERIAL BLOOD FLOW AND OXYGEN CONTENT IN DOGS WITH IMPLANTATION OF THE LEFT INTERNAL MAMMARY ARTERY INTO THE ANTERIOR WALL OF THE LEFT VENTRICLE

DOG NO.	LEFT ANTERIOR DESCENDING CORONARY ARTERY			AORTA				P. A. O_2 CONT. VOL. %	CORONARY SINUS	
	PERIPH. PRESS. (CM. H_2O)	FLOW (C.C./MIN.)	O_2 CONT. (VOL. %)	CONT. (VOL. %)	CAP. (VOL. %)	SAT'N	PRESS. (CM. H_2O)		O_2 CONT. (VOL. %)	PRESS. (CM. H_2O)
1019	33	1.0	14.9	17.6	17.6	100	115	11.9	10.7	8
1023	30.5	1.8	16.1	18.2	19.6	92.8	110	14.8	9.1	4
1001	36	5.0	16.1	18.3	18.1	100	130	13.3	8.3	3.2
1002	30	1.4	18.6	19.8	19.3	100	130	15.2	10.9	4.4
1071	34	0.5	11.5	13.0	14.7	88.4	96	7.0	5.2	2.6
1050	29	4.0	15.0	16.4	15.6	100	130	9.1	4.2	4.6
1261	33	0.5	15.1	17.6	18.4	95.6	79	7.5	5.6	3
1090	35	5.0	17.4	18.8	18.9	99.4	130	13.6	5.2	3
1269	34	1.6	16.2	17.9	18.0	99.4	130	12.4	4.6	3
Average	32.7	2.3	15.6	17.5	17.8		116	11.6	7.1	4

Oxygen Content of the Retrograde Blood Collected From the Peripheral Segment of the Transected Left Anterior Descending Artery.—The results are shown in Table I. The oxygen content of the blood obtained from the distal cut end of the ligated left anterior descending artery ranged from 11.5 to 18.6 volumes per cent, with an average of 15.6 volumes per cent. Concomitantly drawn samples of aortic blood ranged from 13.0 to 19.8 volumes per cent, with an average of 17.5 volumes per cent.

TABLE II. RETROGRADE BLOOD FLOW FROM THE LEFT ANTERIOR DESCENDING CORONARY ARTERY WITH THE INTERNAL MAMMARY ARTERIAL IMPLANT OCCLUDED, AND WITH THE CIRCUMFLEX CORONARY ARTERY OCCLUDED

DOG NO.	FLOW (C.C. PER MINUTE)		
	ORIGINAL	INTERNAL MAMMARY ARTERIAL IMPLANT OCCLUDED	LEFT CIRCUMFLEX CORONARY ARTERY OCCLUDED
1019	1.0	1.1	0.2
1023	1.8	1.6	1.0
1001	5.0	4.8	1.2
1002	1.4	1.4	0.6
1071	0.5	0.5	0.0
1050	4.0	4.1	1.0
1261	0.5	0.4	0.0
1090	5.0	5.0	1.4
1269	1.6	1.6	1.6
Average	2.3	2.2	0.8

Mean Peripheral Pressure of the Distal Segment of the Ligated and Divided Left Anterior Descending Artery.—The mean peripheral pressure of the distal segment of the ligated and transected left anterior descending artery ranged from 30 to 36 cm. of water, with an average of 32.7 cm. of water. Concomitantly measured aortic pressures ranged from 79 to 130 cm. of water, with an average of 116 cm. of water (Table I).

TABLE III. SUMMARY OF PATHOLOGIC FINDINGS IN EACH ANIMAL

DOG. NO.	REMARKS
1019	Reduction in lumen of implanted portion of internal mammary artery ranges from 70 per cent in first quarter to 95 per cent of normal in last quarter of tunnel; due to intimal proliferation. Dense periarterial collagenous cuff has minimal vascularity
1023	Lumen is obliterated throughout length of the tunnel. Dense periarterial collagenous cuff has minimal vascularity
1001	Reduction in lumen ranges from 50 per cent in the first quarter to 95 per cent of normal in last quarter of the tunnel; due to intimal proliferation. Dense periarterial collagenous cuff has minimal vascularity
1002	Reduction in lumen ranges from 95 per cent in first half to 100 per cent of normal in last half of the tunnel; due to intimal proliferation and organized thrombus. Dense periarterial collagenous cuff has minimal vascularity
1071	Lumen is obliterated throughout length of tunnel. Recanalization is seen. Dense periarterial collagenous cuff has moderate vascularity
1050	Reduction in lumen is 90 per cent of normal in all sections of tunnel; due to intimal proliferation. Dense periarterial collagenous cuff has minimal vascularity
1261	Reduction in lumen ranges from 90 per cent in first quarter to 95 per cent of normal in last quarter of tunnel; due to intimal proliferation. Periarterial cuff vascularity is minimal
1090	Lumen is reduced up to 90 per cent of normal in last half of tunnel; due to intimal proliferation. Dense periarterial collagenous cuff has minimal vascularity
1269	Reduction in lumen ranges from 50 per cent in first quarter to 100 per cent of normal in last quarter of tunnel; due to intimal proliferation and organized thrombus. Dense periarterial collagenous cuff has minimal vascularity

Mean Coronary Sinus Pressure and Oxygen Content.—The mean coronary sinus pressure ranged from 2.6 to 8 cm. of water, with an average of 4 cm. of water. The coronary sinus blood oxygen content ranged from 4.2 to 10.7 volumes per cent, with an average of 7.1 volumes per cent (Table I).

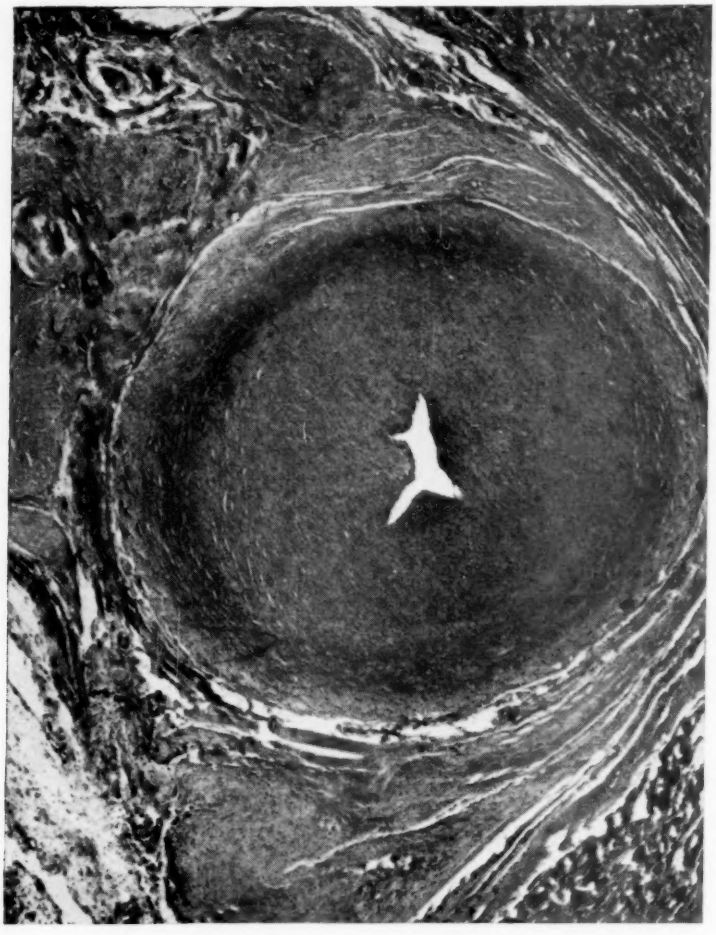

Fig. 4.—(Dog No. 1002). This is a view of the internal mammary arterial implant in the first quarter of the tunnel. There is a 95 per cent reduction of its lumen due to intimal hyperplasia. The collagenous cuff contains only a few small-caliber blood vessels. Hematoxylin and eosin (×26; reduced ¼).

Pathologic Findings.—

A. *Gross findings:* At the time of sacrifice, there were firm adhesions between the operative site and the lungs. There were fine, easily separable adhesions between the lung and the parietal pericardium. The transplanted internal mammary artery was usually buried within a dense mass of mediastinal, fatty, and pleural adhesions. It was not obviously pulsatile and ran directly from the chest wall to the ventricular myocardium without kinking. The vessel was always well splinted and surrounded by adherent mediastinal fat and pleura. The parietal pericardium was adherent to the heart by thin, easily separable adhesions, except at the point of fixation of the internal mammary artery at the distal portion of the tunnel, where they were dense.

Upon removal of the heart and implanted internal mammary artery, the vessel was sectioned transversely to its entrance into the ventricular tunnel. Despite marked narrowing of the lumina, all but one of the specimens were free of thrombosis from the thoracic wall to the myocardial tunnel.

The left ventricular chamber was examined, and the endocardium appeared normal.

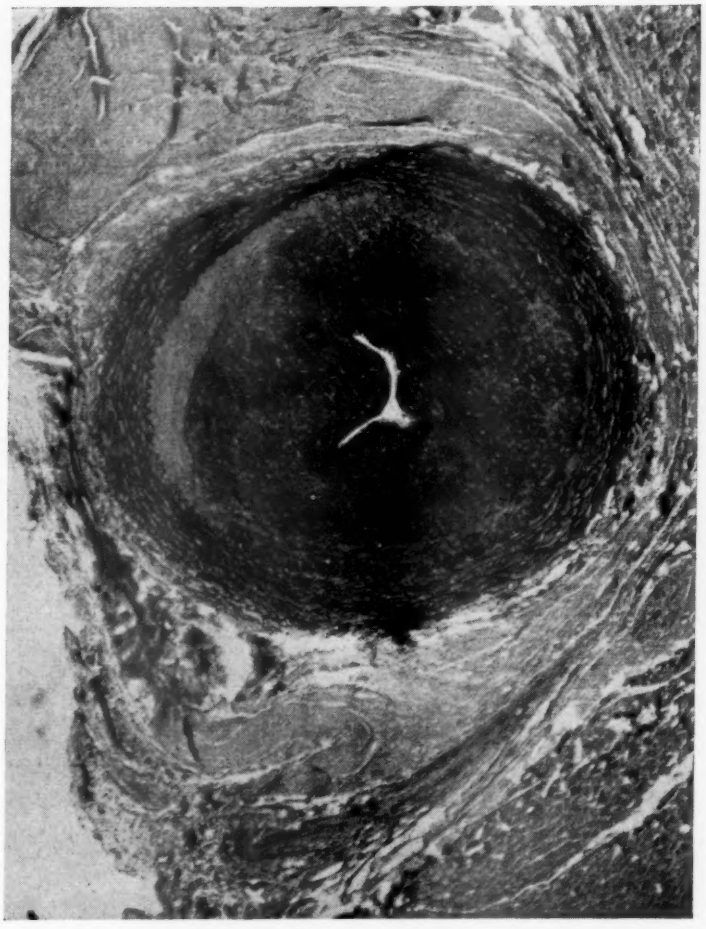

Fig. 5.—This is an elastic tissue stain of the same section as Fig. 4. It reveals a large increase of elastic tissue in the proliferated intima, with none in the perivascular cuff. Weigert's elastic stain (×26; reduced ¼).

B. *Microscopic findings:* For the purposes of examination, the block of myocardial tunnel containing the implanted internal mammary artery was arbitrarily divided into quarters (A, B, C, D), sections being taken from each. These sections were stained with routine hematoxylin and eosin, and Weigert's elastic tissue stains.

All the internal mammary arteries, but one, were free of thrombotic occlusion from the thoracic wall to the myocardial tunnel.

Within the transmyocardial tunnel, the internal mammary artery lumen underwent progressive obliteration due to intimal proliferation of collagenous

and elastic fibers, to which was added in some cases thrombotic occlusion. Fifty-five per cent[5] of the dogs showed a patent lumen throughout the entire course, but the narrowing was so severe it did not appear that an adequate flow of blood could occur. In the other 45 per cent[4] there was thrombotic occlusion with recanalization at some point in the artery's course through the tunnel, usually in the distal half. The vessel in all instances was invested with a dense acellular collagenous cuff in which minimal vascularization by capillaries, arterioles, and small arteries was present. The myocardium was unaltered.

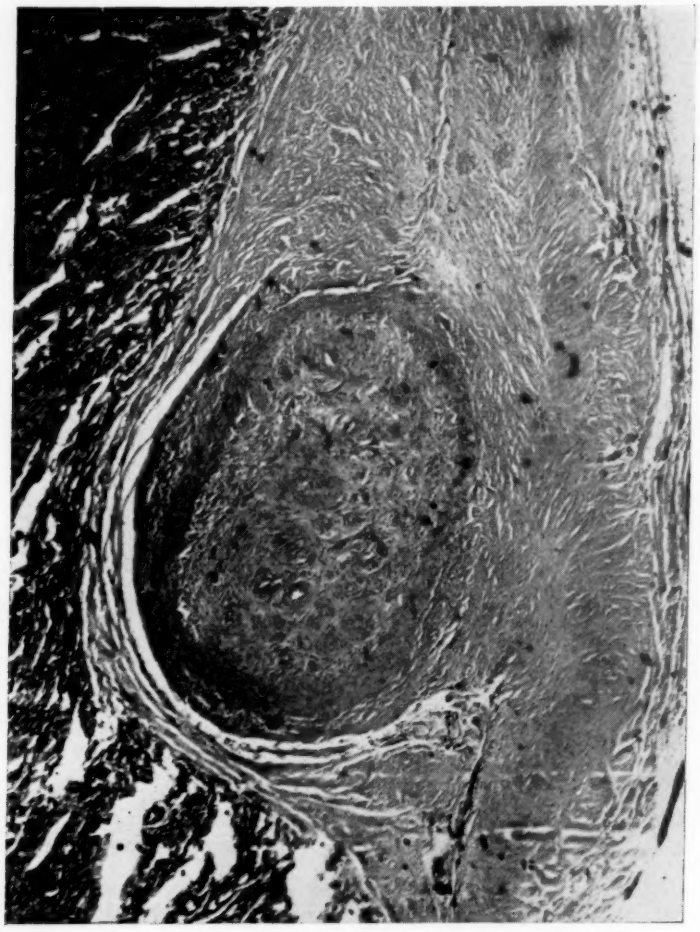

Fig. 6.—(Dog No. 1071). This is a section of the only vessel in which the lumen was completely occluded in the first quarter of its tunnel. There is organization and recanalization of the occluding mass. The perivascular cuff is relatively avascular. Hematoxylin and eosin (×26; reduced ¼).

DISCUSSION

Vineberg has suggested that when the internal mammary artery is implanted into the ventricular myocardium of the ischemic heart, it forms new arterial branches which anastomose with the left anterior descending coronary artery. The concept that a systemic artery implanted into the ventricular myocardium might be able to develop functional anastomoses with the normal arterial system of that organ is most appealing.

It is important to determine whether these anastomoses reported by Vineberg are the expected end result of a local reaction to an implanted foreign body, or if these anastomoses represent newly formed, but permanently functional, channels.

The injection studies reported by Vineberg were all performed in the dead heart. In previous experiments performed on dogs with internal mammary artery implants of six weeks' duration, Neptune and his co-workers,[17] in our own laboratory, have performed injection studies in vivo. The internal mammary artery was dissected to its origin from the subclavian and cannulated. The intercostal vessels remained intact, and a suspension of colloidal carbon was injected at the prevailing systemic blood pressure. Under these conditions, the intercostal arteries and chest wall received most of the suspension, with but a fractional amount entering the left ventricle. In other experiments, the internal mammary was completely dissected, all branches being ligated, and injection studies again were performed in vivo, the suspension being injected at the prevailing systemic pressure. Under these conditions, less than 1 c.c. per minute of the supensions could be injected into the ventricle.

Following these anatomic studies, it appeared to be in order to attempt to evaluate physiologically any increase or change produced in either the intercoronary or the extracoronary anastomoses which might be attributable to the internal mammary-myocardial implant. In previous studies, we have described a simple retrograde coronary arterial flow technique suitable for evaluating changes in the intercoronary arterial anastomoses. Since the retrograde blood from the peripheral segment of a ligated and transected coronary artery is of high oxygen content, it presumably must arise from the neighboring arteries, and therefore must indicate the existence of intercoronary arterial anastomoses. By quantitating this retrograde coronary arterial blood flow, we had an effective method of evaluating changes or augmentation produced in the intercoronary anastomoses.

In our experiments, after the internal mammary artery was implanted into the left ventricular myocardium, the animals were permitted to lead a normal kennel existence for six months, after which time the physiologic experiments were conducted. In general, the mortality from the initial procedure was negligible, the operative technique was simple, and the incidence of thrombosis of the internal mammary arterial implant was low (8.9 per cent).

The most striking and revealing results of our experiments revolve around the retrograde left anterior descending coronary arterial flow studies. When the internal mammary arterial transplant was maintained intact, the retrograde flow ranged from 0.5 c.c. to 5.0 c.c., and averaged 2.3 c.c. per minute. In a series of normal dogs, as previously reported,[12] the retrograde anterior descending arterial flow averaged 2.7 c.c. per minute, with a similar range. Thus, in the present group of Vineberg animals, the retrograde flow approximated that of the normal control animal. We could not determine any evidence of enlargement of the interarterial anastomoses to the anterior descending artery which we could attribute to the internal mammary implant.

Next, it was necessary to determine the actual source of the arterial blood which flowed in retrograde fashion from the distal segment of the transected anterior descending artery and to evaluate the role played by the internal mammary implant. Gregg and his co-workers[18] previously have demonstrated that the retrograde blood flow from the distal segment of the ligated anterior descending artery originates in the left circumflex artery, and can be abolished almost completely by its occlusion.

In the present experiments, after the retrograde flow from the peripheral segment of the coronary artery was measured, the internal mammary graft was clamped, and the flow studies were repeated. Under this condition, the backflow from the anterior descending artery ranged from 0.4 c.c. to 5.0 c.c., and averaged 2.2 c.c. per minute. Practically speaking, this retrograde flow was identical to that recorded prior to the occlusion of the implanted artery.

Next, the internal mammary implant was unclamped, and the left circumflex artery was occluded at its origin. The immediate diminution in the retrograde flow from the peripheral segment of the artery was striking. The flow fell precipitously, and ranged from 0 to 1.6 c.c. per minute, with an average of 0.8 c.c. per minute.

It thus became strikingly obvious that in these experiments, the internal mammary arterial implant failed to contribute any measurable amount of blood to the anastomotic flow of the left anterior descending artery. It was further obvious that the collateral blood flow from the left anterior descending artery originated almost entirely in the unoccluded left circumflex artery, despite the presence of a patent internal mammary implant.

Peripheral coronary arterial pressures (distal segment) were measured. These ranged from 29 cm. to 36 cm. of water, and averaged 33 cm. of water. This approximated that previously reported by Gregg[18] in a normal series of animals and was, therefore, not materially affected by the implantation of the internal mammary artery into the left ventricular myocardium.

The validity of these physiologic experiments was explained further by the results of our pathologic findings. In each of these specimens, an obliterative endarteritis largely occluded the lumen of the implanted vessel within a period of six months. It was obviously impossible for a physiologically significant quantity of blood to flow through these vessels. In every specimen there was periadventitial fibrosis surrounding the implanted artery. There were small arterial vessels in this fibrotic area, but these were sparse. The periarterial fibrous tissue with its few fine vascular structures constitutes what is seen in the final stage of an inflammatory reaction, and indicates that the ventricular myocardium effectively walled off the arterial implant, as though it were a foreign body. Vineberg[7-11] and Glenn[16] have previously demonstrated this striking intimal proliferation. Glenn, too, noted that the development of new vessels tended to disappear at the end of eight weeks, and suggested that the general picture resembled that seen in the "process of organization and canalization."

In his experiments, Vineberg demonstrated the development of an inter-arterial collateral circulation between the newly implanted internal mammary

and the anterior descending coronary arteries. He attempted to substantiate this work by (1) injection studies, (2) mortality results following ligation of the left anterior descending artery, and (3) physical exercise tolerance studies following coronary arterial ligation. Recently, Vineberg has stated that he has been occluding the left anterior descending coronary artery, thus creating an ischemic myocardium, and producing a need for the implanted vessel. Under this condition, he states that the intimal proliferation was much less striking, and anastomotic channels were more abundant.

Our present series of experiments have been performed on a series of animals in which no need for revascularization was created. This may explain the severe degree of our pathologic findings.

We intend to repeat this series of experiments to determine whether the production of an ischemic myocardium will alter our physiologic and pathologic findings.

In the present series of experiments, we have been unable to demonstrate any measurable contribution to the collateral circulation of the left anterior descending coronary artery attributable to the implanted internal mammary artery. In all animals, the interarterial anastomotic blood flow arose almost entirely from the nonoccluded circumflex artery, despite the existence of a patent internal mammary implant. These physiologic results can be explained pathologically by the degree of obliteration of the lumina of the implanted vessels by intimal proliferation. We, too, were able to corroborate the presence of small vessels around the implanted artery and within the cuff of periarterial fibrosis. However, these vessels appeared too small and too sparse to contribute materially to the extraintercoronary anastomotic flow of the left anterior descending coronary artery.

SUMMARY AND CONCLUSIONS

1. In animals in which the internal mammary artery had been implanted into the ventricular myocardium for six months, retrograde blood flow from the distal cut end of the ligated left anterior descending coronary artery averaged 2.3 c.c. per minute, representing a normal amount of the intercoronary arterial anastomotic flow.

2. This intercoronary anastomotic flow was demonstrated to arise almost entirely from the nonoccluded circumflex artery.

3. No increase or change in the intercoronary anastomotic flow could be attributed to the implanted internal mammary artery.

4. Pathologically, the lumina of the implanted vessels were 95 per cent obliterated by the severe intimal proliferation. The vessels were surrounded by fibrous tissue and presented a picture which suggested that they had been walled off by the ventricular myocardium, much the same as a foreign-body reaction.

5. Although a few fine periadventitial vessels were demonstrated, they were believed to be due to terminal phases of the inflammatory reaction. They were small and sparse and were not physiologically significant.

6. We were unable to demonstrate that a systemic artery implanted into the ventricular myocardium for six months could materially increase or contribute to the extraintercoronary collateral anastomotic flow of the interrupted left anterior descending artery.

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LEFT HEART SURGERY IN DOGS DURING RESPIRATORY AND CARDIAC ARREST AT BODY TEMPERATURES BELOW 10° C.

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OPEN cardiac surgery under hypothermia[1, 2] alone is limited primarily by the short period of time during which the heart can be excluded from the circulation without causing anoxic damage to the brain and by the frequency of ventricular fibrillation.

The use of pump-oxygenators or so-called heart-lung machines has great disadvantages since these instruments have been extremely complicated and expensive. In addition, the use of these machines did not provide a bloodless operating field due to the large amount of coronary blood entering the right heart. Further, the danger of air embolism has always been present when the left side of the heart has been opened.

The present work gives evidence that the dangers of anoxia and ventricular fibrillation during hypothermia per se on the one hand and the technical and physiologic difficulties of pump-oxygenators on the other hand have been overcome by combining hypothermia and extracorporeal circulation. In this way, a very small and simple apparatus can be used to oxygenate, to circulate, and to refrigerate the blood at the same time.

The Pump-oxygenator.—The instrument used is based on the principle of dispersing small bubbles of oxygen into the blood and of eliminating the excess oxygen by a defoaming compound.[3] The original motor-driven pump has been replaced by alternating pressure and suction controlled by magnetic valves and without any moving parts.[4] The plastic model used in these experiments represents a smaller and simpler design of the previously established principle.

The venous blood from the caval system and the right heart enters the lower chamber (Fig. 1) at an oblique angle which causes the blood to swirl. This creates additional turbulence and aids in the immediate and complete oxygenation of the blood into which fine oxygen bubbles are forced through a microporous porcelain disk.* Through large holes of a supporting plastic disk, the blood and the free oxygen are led over a very large surface of fine

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*Microporous porcelain disks of controlled pore size were generously supplied by Mr. George V. Jordan, Jr., Selas Corporation of America, Philadelphia, Pa.

nylon fibers which have been coated with Dow-Corning antifoam. This silicone compound causes the oxygen mist to merge into large bubbles which rise readily to the surface of the next chamber. This chamber is separated from the previous one by a flat hard polyethylene valve resting on a plastic disk with a large circular opening and pointing in the opposite direction of the arterial outlet to aid in the removal of all free gas and to ensure a smooth surface for the electrodes. This is of importance for the electrode energizing the magnetic valve opening to the pressure line since bursting oxygen bubbles would cause shorts and make efficient pumping impossible. As an additional safeguard against shorting, this electrode above the arterial outlet is shielded

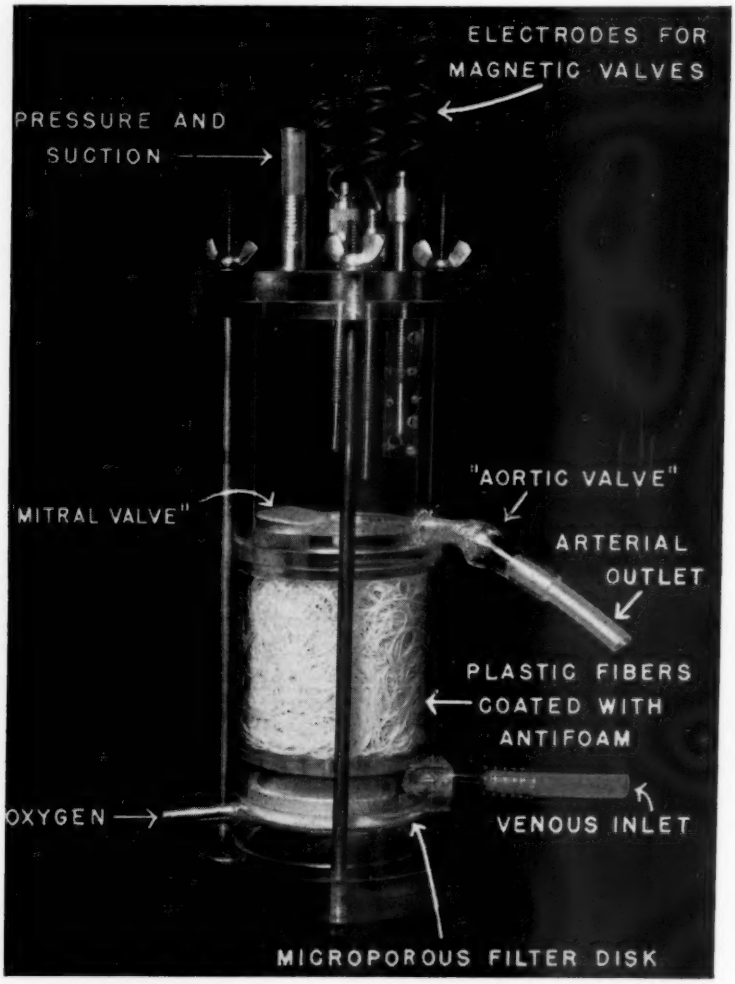

Fig. 1.

with a plastic tube containing multiple openings to permit equalization of pressure and suction. The stroke volume can be regulated by changing the distance between the "pressure" and the "suction" electrode. A plastic tube sealed close to the base of this pumping chamber contains a polyethylene tube which has been drawn out to a paper-thin end under the melting effect of a

hot-air stream, and serves as a flutter valve. The whole plastic unit has a volume of about 400 c.c., is capable of circulating and oxygenating approximately 2 L. of blood per minute, and can be sterilized chemically.

Experimental Procedure.—Large mongrel dogs are anesthetized with intravenous Nembutal, an endotracheal tube is inserted, and the animals are cooled to about 30° C. by covering them with crushed ice. Below 30° C. body temperature the animal is given artificial respiration with a mechanical respirator employing an air-tight system.

The femoral artery and vein are exposed on both sides and 2 mg. of heparin* per kilogram is injected intravenously. Long plastic tubes with multiple longitudinal openings along their entire course are introduced into the femoral veins. The flexible tubes are given more rigidity by putting a cardiac catheter into their lumen. The obturating catheter also prevents bleeding through the openings of the plastic tubing during the cannulization. The obturating catheters are removed after the plastic tubes are tied in place. A short polyethylene catheter is introduced into one femoral artery and a long catheter into the other. In the meantime, a left thoracotomy with meticulous hemostasis has been performed through the fourth intercostal space using high-frequency coagulating electrosurgical technique exclusively. Under manual guidance the long arterial catheter is directed up the aorta into the brachiocephalic artery for a distance of about 2 cm. The exact placing of this catheter is important because, under pressure, a shorter distance of placement from the origin of the brachiocephalic artery will permit the catheter to slip back into the aorta. If, on the other hand, the catheter is inserted further up into the brachiocephalic artery, a carotid artery may be entered with resulting ipsolateral exophthalmos and pressure edema of the brain. Then the pump-oxygenator which has been filled with mammalian Ringer's solution or heparinized whole blood with some additional plasma expander is turned on and when satisfactory blood flow and oxygenation are achieved, the venous catheters are placed so that the tip of one lies in the superior vena cava and the tip of the other in the right atrium. Through a tube attachment in the venous side of the extracorporeal circulation 30 mg. of quinidine sulfate per kilogram and 2 c.c. per kilogram of 5 per cent Triton WR-1339† in distilled water[4] are added to the blood. The quinidine reduces the myocardial irritability and the Triton produces a finer dispersion of oxygen in blood.

A further and selective lowering of body temperature can be achieved by the immersion of a metal coil within the venous side of the extracorporeal circulation into a salt-ice mixture.[5] When the temperature in the mid-esophagus reaches about 20° C., the respirator is turned off and the lungs are allowed to collapse. At about 13° C. heart action ceases completely and the left atrium is entered through the auricular appendage. After the initial removal of blood the heart chamber remains essentially free of blood for the period of open

*We appreciate the generosity of Dr. Joseph P. Webb, Upjohn Company, Kalamazoo, Mich., in supplying us with sodium heparin.

†Generously supplied by R. W. Gormly, Rohm and Haas Co., Philadelphia 5, Pa.

cardiotomy, lasting about one-half hour. Occasionally it is necessary to fill the heart chamber with saline solution since the accumulated blood in the left atrium is insufficient entirely to displace the air prior to closure.

Following closure of the cardiotomy the blood is rapidly rewarmed by immersing the metal coil in a constant temperature bath of 45° C. When the esophageal temperature reaches about 13° C., the first heartbeat can be observed. During this period it is advisable not to manipulate the heart so as not to interfere with the establishment of a normal rhythm. As the heart action becomes more frequent and forceful, the respirator is turned on at about 18° C. Blood warming proceeds until the esophageal temperature reaches about 25° C. at which time the long arterial catheter is withdrawn from the brachiocephalic artery into the lower thoracic aorta. The pump-oxygenator is turned off at about 28° C. At that time the femoral blood pressure measures only 30 to 40 mm. Hg and no time should be lost in transfusing the animal with fresh or decalcified blood until the blood pressure approaches 60 to 80 mm. Hg. Then the long venous catheter can be removed and a short catheter inserted into a femoral vein for a continuous drip of a plasma volume expander* with 8 c.c. of l-arterenol† to stabilize the blood pressure without overloading the circulation at that point. Protamine sulfate‡ in a dosage equal to one-half the amount of heparin is added to the drip.[6] The thoracotomy is closed in layers and a chest tube inserted through a stab wound in the eighth or ninth intercostal space posteriorly using the electrosurgical knife. The tube is attached to a suction pump of approximately 30 mm. Hg negative pressure. This tube is removed only when drainage has ceased. A slight downward drift of the body temperature occurs at that time and a heat lamp directed toward the chest aids the slow rewarming of the animal. Small direct blood transfusions at frequent intervals restore the blood volume. Arterial and venous pressure readings reflect the available blood volume in the systemic circulation more accurately than the hematocrit, which is an unreliable criterion under these circumstances. In spite of spontaneous respiration, artificial respiration at a reduced volume but increased rate is continued for two or three more hours in order to prevent atelectasis and to ensure adequate oxygenation. The hind legs are kept cool as long as the femoral arterial flow is interrupted in order to minimize ischemic damage and anaerobic infections. When the arterial blood pressure is stable the continuity of the femoral arteries is re-established by the insertion of a short polyethylene tube to bridge the defect. Penicillin and streptomycin are given daily for one week.

RESULTS

Body Temperature.—The changes in body temperature are very rapid and extreme (Fig. 2). Within forty minutes the temperature in the right atrium, the mid-esophagus, and the oral cavity drops to about 4 to 6° C., whereas the

*We are indebted to Dr. Joseph P. Webb, Upjohn Company, Kalamazoo, Mich., for a generous supply of plasmoid.

†We are indebted to Mr. Kenneth M. Smoot, Winthrop-Stearns, Inc., New Orleans 19, La., for Levophed.

‡Dr. W. R. Kirtley, Eli Lilly and Co., Indianapolis 6, Ind., kindly supplied protamine sulfate.

rectal temperature undergoes slight changes only. In this manner a temperature difference within the body of 15 to 20° C. can be obtained. This selective hypothermia is due to the greater perfusion of the upper part of the body with cooled blood. Since the cooled blood is directed away from the lower part of the animal the rectal temperature reflects minor changes only. Because of the small differences of temperature changes recorded in the mouth and inside the chest, the conveniently measured esophageal temperature alone can give a reliable guide to heart temperature.

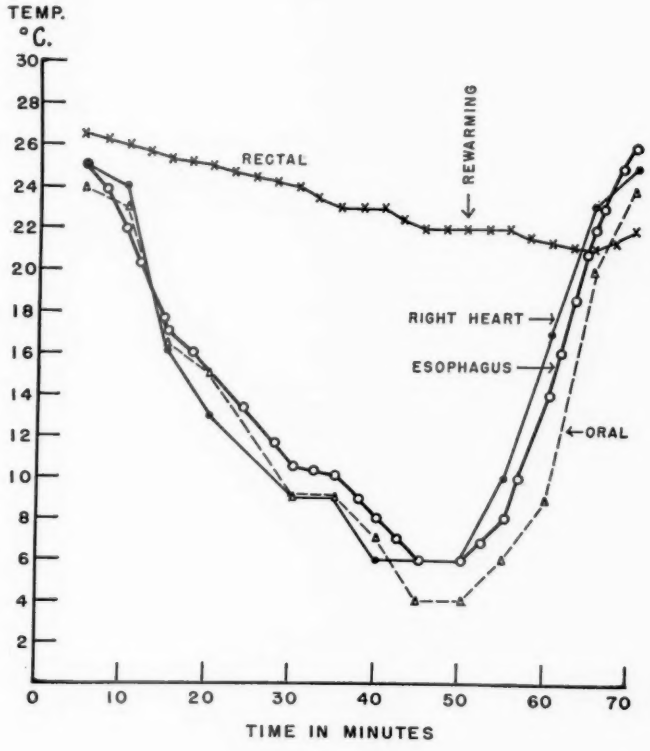

Fig. 2.

Blood Volume.—In order to institute an effective management of fluid balance and blood volume postoperatively, determinations of the circulating plasma and red cell mass are made by means of radioactive iodinated human serum albumen.[7] The radioactive tracer is injected at normal body temperature and the first blood sample taken after fifteen minutes. The second sample is withdrawn during the extracorporeal circulation period after the dog's blood volume is mixed with the content of the pump-oxygenator and added fluid. After the pump is stopped another dose of radioactive iodinated albumen is injected and fifteen minutes later another blood sample is withdrawn. The initial blood volume of the animal, the entire circulating blood volume during the perfusion, and the blood volume remaining in the animal after the experiment (Table I) reflect the expected increase in the circulating blood volume due to the large addition of fluid pumped by the instrument.

In seven animals the instrument was primed with Ringer's solution and the same fluid was added whenever the blood flow decreased. In another group of seven dogs the instrument was filled with heparinized whole blood, and whole blood with some additional plasma expander was added to the circulation. The amount of Ringer's solution added must have been mixed completely with the radioactive tracer since the circulating blood volume during the perfusion amounted to the exact sum of the initial blood volume and the fluid added. This did not hold true when the instrument and all the tubing were filled with whole blood since the total circulating volume was found to be far in excess of the known amount added. The explanation for this obviously fictitious value may be found in the increased viscosity, blood sludging, and stagnating peripheral circulation in severe hypothermia[1] which probably prevented complete mixing. The most significant difference after perfusion with crystalloidal or colloidal fluid was the rapid disappearance from the vascular bed of almost 1 L. of Ringer's solution fifteen minutes after termination of the mechanical circulation. Whereas the total blood volume remained constant after priming of the instrument with whole blood, there remained only about 75 per cent of the initial blood volume and only about 35 per cent of the initially circulating red cell mass in the animal when Ringer's solution was used (Fig. 3). This deficit in plasma and cells indicates the quantity of blood transfusion required to return the animal to physiologic conditions.

TABLE I

	TOTAL BLOOD VOLUME				RED BLOOD CELL VOLUME		
DOG NO.	INITIAL	VOLUME ADDED	DURING	AFTER	INITIAL	DURING	AFTER
			Ringer's Solution				
1	2,000	1,900	4,943	1,148	880	693	173
2	1,366	3,000	5,530	1,210	656	—	190
3	1,715	2,250	3,608	1,195	823	848	287
4	1,292	2,400	3,443	998	550	603	164
5	1,438	1,950	3,020	1,076	660	650	258
6	1,326	2,400	3,085	993	437	550	183
7	1,566	2,450	3,515	1,182	736	845	254
Mean	1,529	2,336	3,878	1,115	677	698	216
S.E.M.	±96	±138	±365	±32	±57	±51	±17
			Whole Blood With Plasma Substitutes				
1	1,516	—	4,810	2,170	576	1,350	440
2	1,598	3,150	4,690	1,930	623	1,230	560
3	1,532	1,900	3,812	1,396	—	—	—
4	1,470	1,800	3,677	—	500	647	—
5	1,795	1,800	4,928	2,018	915	2,168	855
6	1,398	1,450	3,173	1,166	628	1,103	408
7	1,421	1,500	3,490	1,374	568	1,360	494
Mean	1,533	1,933	4,083	1,676	635	1,310	551
S.E.M.	±50	±256	±269	±169	±74	±184	±63

Survival.—It became apparent from the normal recovery of these dogs after left cardiotomy below 10° C. body temperature that long-term survival will depend on the quality of postoperative management. This first impression was confirmed in the result of thirteen consecutive experiments (Table II).

Nine animals survived without any clinically detectable ill effect and were observed for one month. Except for scar tissue and adhesions, autopsies failed to show any gross pathologic changes.

One animal died of hemothorax after one day. One animal developed a gas gangrene infection in a hind leg and was sacrificed one week after the experiment. This anaerobic infection was probably due to the rewarming of

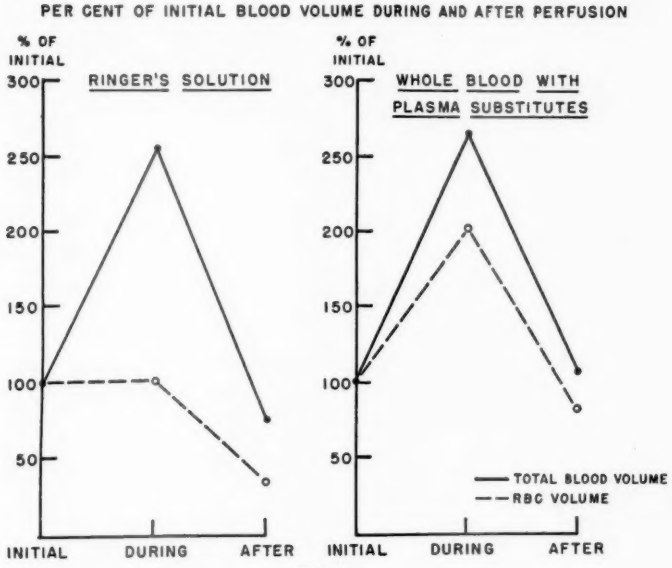

Fig. 3.

the ischemic muscle while the blood pressure was still recorded from the femoral artery. Cooling of the hind legs prevented further infections. One animal was found dead four days after the operation and the cause of death could not be ascertained. One animal died from an aortic thrombosis originating from a polyethylene tube in a femoral artery.

TABLE II. LEFT CARDIOTOMY DURING HYPOTHERMIA BELOW 10° C.: RESULT OF 13 CONSECUTIVE EXPERIMENTS

	WEIGHT (KG.)	DURATION BLOOD-COOLING (MIN.)	DURATION RESPIRATORY ARREST (MIN.)	DURATION CARDIAC ARREST (MIN.)	LOWEST HEART TEMPERATURE (°C.)	DURATION CARDIOTOMY (MIN.)	DURATION BLOOD WARMING (MIN.)	BLOOD FLOW (C.C./KG./MIN.)
Average	19	45	42	26	6	26	18	47
Range	16-22	27-68	26-53	21-35	3-11	17-42	13-20	32-77
			1-month survival		9			
			Dead		4			
			Cause of death		Hemothorax			
					Infection			
					Aortic thrombosis			
					Unknown			

DISCUSSION

The profound degree of hypothermia produced by the refrigeration of blood passing through a pump-oxygenator lends itself most advantageously

to open cardiac surgery. The motions of the lungs and of the heart are arrested and greater technical accuracy is attainable. By the cannulization of peripheral blood vessels only, the operating field is not crowded by tubes. This shortens the surgical procedure and avoids trauma to the great vessels in the chest. Due to the low oxygen consumption of animals during profound hypothermia, one-fifth or less of the normal cardiac output circulated and oxygenated outside the body is sufficient; therefore, a small and simple pump-oxygenator can serve the purpose. With the present one-chamber plastic unit, an extreme degree of overoxygenation is produced in which arteriovenous differences of oxygen and carbon dioxide content are less than one-half one volume per cent.[8] We are dealing, then, with an animal practically devoid of venous blood and, surprisingly enough, such an "unphysiologic" condition is harmless. At no time during the experiment does the nervous system, the heart, or the viscera suffer from anoxia or from carbon dioxide retention and, therefore, no time limit is set for the careful exploration and repair of intracardiac lesions.

As long as the pump-oxygenator substitutes for the functions of the heart and the lungs, prolonged ventricular fibrillation is inconsequential[9] and normal sinus rhythm can always be re-established by electrical shock. It is more desirable, however, to avoid ventricular fibrillation and electrical defibrillation altogether and the present study shows that canine hearts can be cooled to asystole without the usually encountered arrhythmias during hypothermia. This can probably be explained by the avoidance of some of the known causes of cardiac crisis in prolonged exposure to cold, particularly anoxia, carbon dioxide retention, increased central venous pressure, and increased blood viscosity.[10] Of at least equal importance is the reduction of coronary flow to the low oxygen requirement of a myocardium in hypothermic asystole. By the division of the return of the oxygenated blood from the instrument into the brachiocephalic and into one femoral artery, a very low perfusion pressure is created in the ascending aorta resulting in minimal coronary flow. As the temperature falls the heartbeats become less frequent and forceful, and below 20° C. the heart is unable to eject a large coronary inflow. The drastic reduction of coronary flow during profound hypothermia prevents cardiac dilatation and at the same time creates the long-sought bloodless field for open cardiotomy.

The observation on the preventive effect of quinidine sulfate on the incidence of ventricular fibrillation[11, 12] has been confirmed in hypothermia by blood-cooling.[13] Under the experimental conditions of this study, ventricular fibrillation during the cooling period can be ignored because profound hypothermia will arrest all heart activity. During the rewarming period, however, the reduction of myocardial irritability by quinidine has aided in the prevention of ventricular fibrillation.

At the first glance the dilution of blood to a hematocrit of about 25 per cent would seem a priori to be an objectionable or even dangerous step since hemoglobin and plasma proteins are temporarily reduced to low levels. However, the endeavor to keep all known factors "physiologic" becomes a severe

handicap during hypothermia and, therefore, the conditions which normally maintain the "milieu intérieur" have to be drastically changed in order to achieve the survival of large nonhibernating mammals at a body temperature close to the freezing point of water. In this context the dilution of blood with equal parts of Ringer's solution plays an important role. As the body temperature approaches 0° C. the oxygen dissociation from hemoglobin becomes negligible and the red blood pigment becomes less important as carrier of oxygen. On the other hand, the solubility of oxygen in water increases steeply and as much as four volume per cent of physically dissolved oxygen can be found in the plasma of dogs at 3° C. body temperature. This amount of oxygen is sufficient to cover the minimal requirement at that temperature and, hence, under these conditions the life of the dog can be maintained without hemoglobin.[14]

The dilution studies with radioactive iodinated albumen indicate that the entire volume of the diluted blood is available for the artificial circulation, whereas the highly viscous whole blood does not completely mix with the tracer during severe hypothermia. After the perfusion no further changes in blood volume take place if the entire system is filled with whole blood and additional blood transfusions are contraindicated. Quite different conditions are encountered if the blood is diluted with Ringer's solution. While all the added fluid is available to the pump-oxygenator during the perfusion, none of it remains available to the heart after fifteen minutes. This rapid disappearance of saline solution from the vascular space of hypothermic dogs[5] exceeds the disappearance rate of sodium[24] after intravenous injection in normothermic human beings.[15]

This marked depletion of blood volume and of red cell mass in particular makes it possible to replace all lost fluid and corpuscular elements with fresh, coagulable blood. Further advantages of the induced hemodilution during the perfusion are the absence of hemolysis, the reduction of the required dose of heparin from 10 to 2 mg. per kilogram, and the greater ease of defoaming.

The decline in myocardial efficiency at lower temperatures was observed a long time ago,[16] and more recently attention has focused on extrasystoles and ventricular fibrillation as the cause of death in prolonged exposure to cold.[17, 18] By substituting a mechanical device for the failing heart, we have shown that dogs can survive a body temperature of 0° C.[8] Although this finding does not contribute to the understanding of myocardial metabolism in hypothermia it constitutes a crucial counterproof experiment as to cardiac failure as the cause of death and in this way confirms the old dictum: "sublata causa, tollitur effectus."[19]

SUMMARY

A small, plastic, one-chamber pump-oxygenator is described which is based on the previously established principle of gas dispersion.

By cooling the blood in the extracorporeal circuit the body temperature of dogs can be lowered below 10° C., and during prolonged respiratory and cardiac arrest, open cardiotomy can be performed. Under these conditions

anoxia, ventricular fibrillation, coronary flow, or air embolism do not interfere with intracardiac surgery. Thirteen dogs survived open left cardiotomies without any clinical evidence of ill effect. Four animals died of postoperative complications.

We acknowledge gratefully the statistical evaluation of the data by Mrs. Con Ball and the technical assistance of Mr. Raymond M. Jones.

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IN VIVO VISUALIZATION OF LYMPHATICS

An Experimental and Clinical Study With Reference to the Rectum

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IT IS common experience that the number of five-year survivals in rectal carcinoma does not approach the number of cases which the surgeon at operation resects in hope of cure. Numerous investigators[2, 5, 7, 11, 12, 14, 15, 20] have presented figures which indicate in their average that the five-year survival without evidence of residual disease is (a) 50 per cent in all cases operated for cure, (b) 35 per cent where positive nodes are present, and (c) 65 per cent or higher where no positive nodes are found. These figures include all tumor locations within the rectosigmoid and rectum, all grades according to the Broders' classification, and all stages according to Dukes's classification. That is, the evaluation of the curability of a group of patients in which preoperative study and direct inspection of the viscera indicate no distant metastases is mistaken about half the time. The reasons for the failure of correct evaluation fall into three categories. Some patients already have invisible distant metastases present at the time of operation. Some patients may succumb because of dissemination of tumor emboli already present in local lymph vessels to distant nodes by manipulation of tissues at surgery, and many patients fail to cure because of local recurrence. We know of no way to circumvent the first two categories. The last reason for failure to cure seemed vulnerable to attack.

The local recurrence represents either implantation at the time of surgery, or failure to extirpate the disease when it is confined to its original site and regional nodes. Cole[6] felt that seeding of tumor cells at surgery was responsible for half of the 16 per cent local recurrence rate in his series of fifty-five anterior resections. More recently, during the course of experiments relating tumor implantation to bowel preparation, Vink[24] showed that the Brown-Pearce tumor could be readily implanted on transected rabbit bowel, particularly if prepared with antibiotics. The largest number of local recurrences exclusive of implants in suture lines evidently represents positive nodes or tumor nodules remaining in the operative field. This must be true even of many of the 35 per cent of patients who do not survive in the group where positive nodes are reported absent. The enlarged, hard nodes almost entirely replaced by tumor are not often missed. More likely to be left behind in the fat in which they lie are normal-appearing and feeling nodes

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containing small tumor islands. Failure to remove these nodes, we feel, is due to the surgeon's inability to see them at the time of surgery. The present study, therefore, is an attempt to evolve a consistently and easily reproducible method of preoperative preparation of the patient so that the nodes draining the rectum are grossly visible at the time of surgery. It is an attempt to increase the salvage rate in the group of rectal and rectosigmoidal carcinomas that is lost to local recurrence. The principle utilized is not new, but a satisfactory discipline applicable to this region has not, to our knowledge, been previously published.

SELECTION OF MATERIAL

Vital dyes have been used extensively in lymphatic investigations. This is especially true of Evans blue dye*; much is known concerning its behavior. It is synthesized by coupling together one mole of diazotized-o-toluidine and two moles of l-amino, 8-naphthol-2, 4 disulfonic acid; hence it is also known as T-1824. It is water-soluble and deep blue, but changes to a colorless preparation above pH 8. In serum it forms a complex anion which combines with albumin; the reaction is complete within seconds.[1] Anywhere from 8 to 14 moles of dye combine with a single mole of albumin. Up to concentrations of 0.004 per cent it is bound to albumin exclusively, but if sufficient dye is present it combines also with the globulins.[16, 21]

In tissue the dye is taken up by reticuloendothelial cells and macrophages.[27] After intravenous injection it is noted in histiocytes, monocytes, fibroblasts, and lymphocytes around tumors.[8, 9] Similarly, it has been noted in the stroma of tumors[3] but never in the neoplastic cells themselves. It was our concept, following the work of McMaster,[17] that a depot of dye could be deposited in the interstitial fluid compartment of the lower rectum of such small volume that the local tissue pressure dynamics would be little disturbed, but of sufficient concentration that enough dye would be available for distant dissemination under essentially physiologic mechanisms of transport and distribution except as modified by the presence of tumor. Under these conditions the flow of dye would follow the pattern of lymph flow. We felt that the addition of hyaluronidase and consequent breach of interstitial fluid-lymphatic interface might create new paths of flow not normally operating. We feared, too, the introduction of tumor emboli into a previously closed lymph system.

CLINICAL BACKGROUND

Accurate descriptions of the rectal lymphatics based on injections of Prussian blue mixtures in cadavers (Gerota's method) have existed for at least fifty years. In 1925, Villemin and associates,[23] using nonvital dyes, described in detail the lymphatic pattern in the rectum of the stillborn fetus. In 1933, Wood and Wilkie[26] injected the rectum of a dying man with trypan

*Evans blue dye 4 per cent aqueous solution. This preparation was checked in our laboratories at pH6.35.

blue (T-1836) and at autopsy, an unspecified time thereafter, noted staining of nodes near the origin of the external iliac veins. Sauer and Bacon,[22] using a similar technique in 1952, with T-1824, were able to demonstrate the middle hemorrhoidal lymphatic pedicle in specimens from patients injected two hours prior to surgery. Previously, McMaster[17] had shown that Patent blue V (a vital dye) could be used to trace cutaneous and subcutaneous lymphatics in the living, and Burch[4] had outlined the lymphatics of the eyelid using the same dye. Kinmonth,[13] using Patent blue V, succeeded in outlining the lymph trunks of the leg at operation by a previous subcutaneous injection and massage. Weinberg[25] reported the injection of Pontamine sky blue and hyaluronidase in the neighborhood of neoplasms at the time of laparotomy including those of the colon but not the rectum. He noted dispersion to regional nodes which was inconstant because of the short time interval between injection and resection.

LABORATORY EXPERIENCE

A variety of materials were injected subcutaneously into 500 gram guinea pigs in varying volumes and concentrations to one side of the anus. The groin nodes were inspected. These included inguinal, femoral, and iliac nodes as well as two or three nodes on each side related to the nipples which in the guinea pig are in the groin. Methyl red, Higgins ink, aqueous eosin, aqueous carmine, lamp black suspension, crystal violet, and methylene blue proved unsatisfactory for our purpose. Evans blue and Niagara sky blue 6B were equally satisfactory for outlining lymphatics. Since staining with the former was found to persist longer, it was retained for study. Volumes of dye were selected so that after injection the local area of diffusion remained restricted to one side of the anus. At intervals varying from twelve hours to four weeks the lymph nodes were exposed under intraperitoneal Nembutal anesthesia.

It was soon apparent that in normal guinea pigs 0.25 c.c. of 4 per cent Evans blue dye consistently stained all the inguinal, femoral, and groin nodes on the injected side (Fig. 1). Some nodes on the contralateral side were frequently stained as well, although less intensely. Larger amounts of dye consistently stained all the groin nodes bilaterally as well as the para-aortic nodes (Fig. 1). These larger amounts of dye tended to diffuse around the anal circumference. Dye was found only in the immediate area of injection, in nodes, and in lymphatic vessels. Histologic section of all blue-stained tissue masses excepting the injection site proved without exception to be lymph nodes. Intervening tissue was unstained. The nodes were thoroughly stained and easily visible in contradistinction to those in uninjected animals. The dye washes out with the usual technique of preparing sections, interfering in no discernible way with the usual coloration on hematoxylin and eosin stain. No morphologic changes were noted on microscopic examination which could be ascribed to the dye. In some animals examined twelve to eighteen hours

after injection, afferent and efferent lymphatic vessels could be seen connecting nodes. These were noted to constrict spontaneously along the entire length of the exposed vessel, emptying and then refilling with dye-colored lymph. This occurred as frequently as three times a minute or not at all during one-half hour of observation. The lymph vessels could be provoked to constrict by stroking them with an instrument. Valves were not demonstrated in the lymph channels observed in guinea pigs.

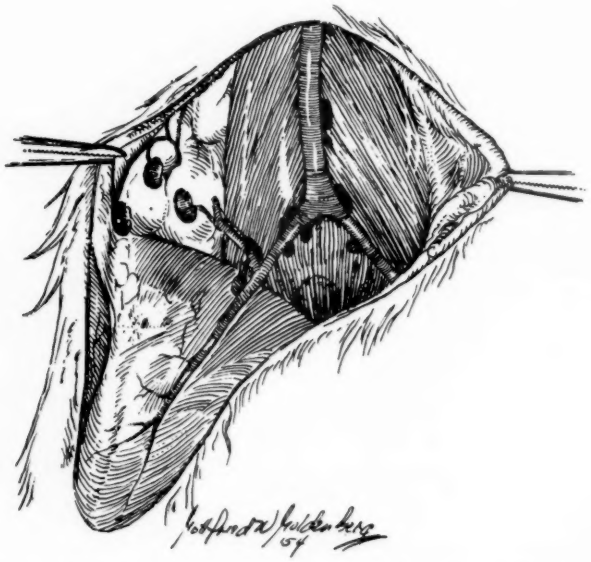

Fig. 1.—Drawn from colored photographs. Guinea pig. Twenty-four hours following injection (perianal) of Evans blue dye. All inguinal, femoral, iliac, and groin nodes stained. Some para-aortic nodes stained.

In dogs, Evans blue dye was injected into the submucosa of the rectum approximately 3 cm. above the pectinate line through an anoscope. This level was chosen in hope of staining the inferior as well as the superior lymphatic pathways of spread. Trial and error demonstrated that 1 c.c. of 4 per cent Evans blue dye was a satisfactory dose for a 10 to 20 kilogram dog. The aliquot was entirely placed in one location or divided in doses at several points circumferentially at the chosen level. With either method of injection this dose of dye produced diffusion within the mucosa and submucosa entirely around the circumference of the bowel. At laparotomy, twenty-four hours later, mesenteric nodes were immediately visible on opening the abdomen. There was relatively little fat surrounding them in dogs which in all respects seemed well nourished. When a leaf of peritoneum from one side of the pelvic mesocolon was reflected and the dissection carried as high as the celiac axis and as wide as the abdominal parietes, all the nodes of the hypogastric, common iliac, and para-aortic groups as high as the celiac axis with many of the intervening lymphatic channels became visible (Fig. 2). Dissection in the hollow of the sacrum revealed staining of the median

Fig. 2.—Dog. Drawn from a colored photograph, twenty-four hours after injection of Evans blue dye into rectal submucosa. Pelvic colon is on left; aorta and inferior vena cava are on right. Stained nodes are black.

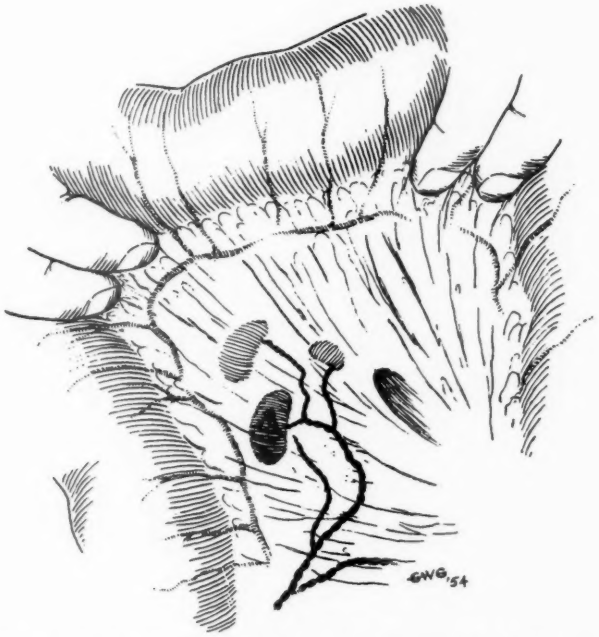

Fig. 3.—Dog. Thirty minutes following injection of Evans blue dye into rectal submucosa. The location of valves in the stained lymphatic vessels is evident. Drawn at laparotomy.

sacral and lateral sacral nodes. When the pubic symphysis was divided and the hemipelves distracted, nodes of the middle hemorrhoidal pedicle were noted to be stained.

Repeated laparotomies on the same dogs disclosed that the staining gradually fades from the nodes, but may faintly persist for as long as ten weeks. If, when the dye has completely disappeared, the injection is repeated, the same filling of the nodes is seen indicating that no gross functional changes are produced by the dye. In three dogs, the abdomen was opened thirty minutes after the rectal injection; most of the usual nodes were found to be stained. The lymphatic vessels were dilated and had a beaded or segmental appearance (Fig. 3), indicating the location of valves. In all mesenteric lymph vessels where valves were noted they were placed at perfectly regular intervals. This differs from the situation in the human limb, where they have been described as being more frequent distally and less frequent proximally. In these latter three animals the cisterna chyli was noted to contain pale blue lymph within forty-five minutes of the time of injection. A single dog was anesthetized, the abdomen opened, and the rectum then injected. Within ninety seconds, a dye containing lymph vessel was noted in the pelvic mesocolon, and within five minutes, one of a group of three more proximal mesenteric nodes was stained (Fig. 3). Gentle stroking of the lymphatic vessels or dissection near them induced spasm, rapid emptying, and within a few minutes refilling.

The dye combines with interstitial fluid proteins at a rate determined by the mass law. Initially, the rate of flow is high, therefore charging the lymph vessels with dye so that they are engorged and the valves stand out. After twenty-four hours, as the quantity of dye available in the depot diminishes, the lymph vessels are less distended and the valves are not apparent. In a few instances where large amounts of dye were injected, the fine lymphatic mesh work of the entire omentum was clearly outlined on opening the abdomen. Gentle manipulation for five minutes caused complete disappearance of all dye from the omentum.

Hysterectomy was performed on one dog found at laparotomy to be pregnant. No dye was found in any of the almost term fetuses. In dogs given 1 c.c. and guinea pigs given 0.25 c.c. of dye with autopsy at twenty-four hours or more after injection, no gross dye was found in the brain, bone marrow, heart, lungs, adrenals, kidneys, liver, or spleen.

Diffuse staining of the skin, adrenals, renal cortex, and arterial adventitia, intima, and endocardium occurred in two animals. These were one dog and one guinea pig each given approximately five times the standard dye dose used. These died, respectively, of sepsis and hemorrhagic shock postoperatively. A possible explanation of this phenomenon is given by Gersh.[10] On the basis of suggestive experimental evidence he postulated that under these conditions and others there is depolymerization and softening of ground sub-

stance in certain locations so that it becomes water-soluble. The selective preference of Evans blue dye for such altered ground substance after intravenous injection he found to be nearly specific.

CLINICAL EXPERIENCE

Patients were selected who had a variety of large bowel lesions. An anoscope is inserted into the rectum and a level chosen between the pectinate line and the lowest valve of Houston. The mucosa is swabbed clean and a No. 22 spinal needle is inserted through the mucosa and slid into the submucosa for approximately 2 mm. Some indication that the needle tip is in the submucosa is given by a sensation of mobility which it has when properly placed. If no blood is seen to issue from the needle hub, it is connected to a syringe containing the measured amount of dye which is then injected.

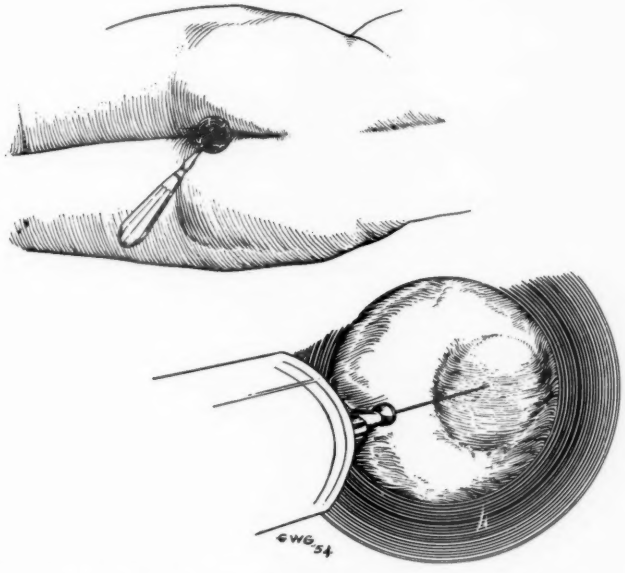

Fig. 4.—Position of patient and needle immediately following dye injection.

Two cubic centimeters of 4 per cent dye was used in most of the cases. If properly done, no dye spills into the lumen of the bowel and a mound of mucosa is raised up which shortly turns blue (Fig. 4). A mild degree of discomfort was noted by a few patients, particularly if the rectum was sore from recent enemas. The addition of 1 c.c. of 2 per cent procaine to the injection mass rendered the procedure painless. To date, nineteen patients have been injected and operated upon within twelve to seventy-two hours with no adverse effects or staining of the skin or viscera other than the rectum. It is important to make the injection exactly as described since a deep injection will stain perirectal tissues.

When the abdomen is opened no dye may be visible anywhere, beyond a slight stain in the cul-de-sac in a few cases, because of large amounts of fat

in the mesocolon. In two patients with little mesenteric fat, the entire stained inferior mesenteric chain of nodes and para-aortic nodes in the vicinity of the origin of the inferior mesenteric artery were immediately visible on opening the abdomen. As the dissection proceeds, various dyed node groups come into view. In one patient undergoing right hemicolectomy for appendical carcinoma, no nodes related to this portion of the bowel were stained.

One patient had carcinoma of the bladder with involvement of the rectum and underwent pelvic evisceration. The hypogastric, common iliac, and median sacral nodes as small as 2 mm. in diameter were stained. Six stained and no unstained nodes were found in the portion of the mesocolon removed. All nodes appeared grossly normal although some contained microscopic carcinoma.

Thirteen patients had carcinoma of the rectum or rectosigmoid. Three had anterior resections, and six had abdominoperineal resections. Another patient suffered a perforation of the rectum through his carcinoma following an enema the evening before his operation was scheduled. He died of peritonitis, no operation having been done. He had been injected three days previously and his nodes were examined at post mortem. Three patients were obviously inoperable, and no tissue was resected. The nodes were, therefore, unavailable for inspection. The dye injection was made caudad to the tumor in all instances except in one patient who had carcinoma at the pectinate line and was injected just cephalad to the tumor. In all, eleven excised specimens were available for study. Local dye diffusion in the rectum was circumferential and always failed to stain the primary tumor (Fig. 5). Injection of 1 c.c. in each of two lateral quadrants stained more nodes than injection at a single site. All mesenteric, hypogastric, and common iliac nodes stained in two patients. Stained mesenteric nodes were noted four times while placing arterial ligatures in preparation for resection, and it was simple to choose another location proximal to them. After removal of the specimen any stained nodes residual in the operative field are easily visible and may be removed. On pathologic examination the arteries in the specimen are laid open throughout their length, exposing the stained mesenteric nodes (Fig. 6) which are immediately visible to the pathologist. Ten cases contained some unstained nodes in the mesocolon. Normal nodes stained homogeneously. Stained nodes containing a few microscopic fields of tumor tissue were grossly indistinguishable from nodes which were free of tumor. Nodes which were partially replaced by tumor took no dye in the tumor portion. The normal residual portions of such nodes were stained. This was sufficiently characteristic at times that gross determination of metastatic involvement was demonstrated (Fig. 7). In two abdominoperineal specimens which included the inferior mesenteric artery from its origin at the aorta, the nodes, without exception, were stained (Figs. 5 and 6). In three other abdominoperineal specimens with ligation of the vessel at this point, almost all nodes, including the group at the vessel's origin, were stained. In two of

Fig. 5.

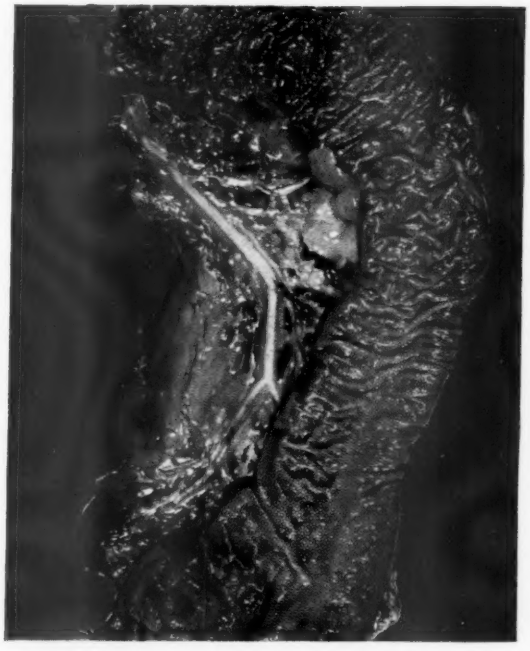

Fig. 6.

Fig. 5.—Man, Seventy-two hours following preoperative injection of 2 c.c. Evans blue dye into rectal submucosa. The carcinoma is the small unstained lesion near the bottom of the illustration. Failure to stain the primary tumor is a constant finding. The area of local dye diffusion is visible. The nodes of the middle hemorrhoidal pedicle as well as those of the superior hemorrhoidal and inferior mesenteric pedicles are stained to the origin of the inferior mesenteric artery. The same distribution of dye was obtained with large annular lesions so long as the lymph pathways were not blocked.

Fig. 6.—Man. Same specimen as in Fig. 5, showing close-up view of nodes at origin of the inferior mesenteric artery which has been rotated to show them better.

these patients para-aortic nodes were stained. In the autopsied patient, also, the nodes at the origin of the inferior mesenteric artery were stained. Ligature of the vessel even 2.5 cm. distal to its origin would have missed the constantly present most proximal group of nodes. This was stressed by Moynihan[19] in 1908, when he advocated for the first time routine ligation of the inferior mesenteric artery at the aorta for rectal and sigmoidal carcinoma.

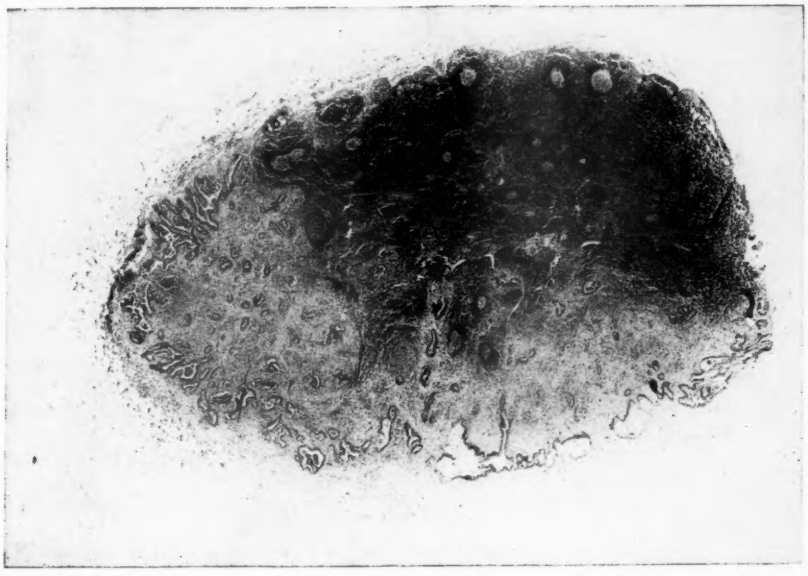

Fig. 7.—Human lymph node. The neoplastic portion of the node was unstained; the normal portion was stained deep blue. Gross determination of metastasis was possible.

DISCUSSION

In the normal experimental animal all nodes draining the rectum including the para-aortic group can be stained consistently. In patients with carcinoma unstained normal nodes have been found a few centimeters from stained nodes. Para-aortic nodes have twice been noted to be stained. Failure of some nodes to stain may merely reflect an insufficient depot. The quantity of dye thus far injected in patients is relatively far less than that used in animals. It may be that under conditions of diminished volume flow, lymph by-passes some nodes. For this reason, it is important that an interval be present between injection and operation during which the patient may walk about, receive enemas, and have bowel movements. Lymphatic obstruction accounts for nonstaining of some nodes. Certainly, the dye being an integral part of the lymph protein molecule must go everywhere that lymph from the injected area can flow in any particular individual. No human lymphatic vessels have been visualized to date by us in the pelvic region. It should be clear that the technique of preoperatively staining the hypogastric and common iliac nodes by a rectal injection of Evans blue dye is equally applicable to neoplasms of the bladder, cervix, and uterus. Should

para-aortic nodes be demonstrated to consistently stain in human beings, the method would be applicable to tumors of the testes, ovaries, and possibly other organs.

SUMMARY

A preliminary report is made on a method of in vivo demonstration of the rectal lymphatics with a vital dye in animals and human beings.

Certain observations clearly indicating the effect on lymph flow of handling of viscera have been made in dogs.

Gross visualization at the time of surgery of all regional nodes up to the origin of the inferior mesenteric artery and of some para-aortic nodes has been found to be possible although inconstant in patients with rectal carcinoma, after preoperative rectal dye injection.

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Case Reports

FIBROMYXOMA OF THE JEJUNAL MESENTERY

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MESENTERIC neoplasms occur infrequently. In 1932 Rankin and Major[1] collected twenty-two cases from the files of the Mayo Clinic. These were seven cysts, seven benign solid tumors, and eight malignant tumors. Mac Nab and Menzies[2] estimated that by 1949 about 700 cases of mesenteric cysts had been reported. Freeman[3] cited five mesenteric cysts in 89,000 hospital admissions at the Watts Hospital between 1938 and 1949. Solid mesenteric tumors are less frequent than cystic lesions. Hart[4] found 186 reported cases of solid tumors of the mesentery. He stated that cystic tumors are more frequent in the ratio of 2:1.

Symptoms vary, depending on the nature, location, size, and complications of the tumor. There may be severe attacks of intra-abdominal pain, intestinal colic, nausea, and vomiting. Abdominal distention and constipation may be present. On the other hand, an intra-abdominal mass with no other findings may be noted on a routine examination of an asymptomatic patient. The presence of a mobile mass, where the main motion is vertical to the line of attachment of the mesentery, is suggestive. Roentgenogram may reveal extrinsic pressure deformity on various intestinal viscera and may occasionally show intrinsic encroachment of the intestinal lumen. Hemorrhage into the tumor, valvulus of the small intestine, or mechanical obstruction of the bowel will influence the clinical picture correspondingly.

In this case report, the tumor was discovered on a routine post-partum checkup visit of a 28-year-old woman. It was not detected during the preceding pregnancy and did not interfere with it.

CASE REPORT

Case No. 53-1376. K. T., a white woman 28 years old, was found to have a large movable asymptomatic tumor in the left upper abdomen shortly after being delivered of a normal baby. She was admitted to the Kew Gardens General Hospital on Feb. 22, 1953, and discharged March 4, 1953. She had noticed that the abdomen seemed more protuberant than expected following her delivery six weeks before. In 1942 an appendectomy had been performed. The history was otherwise irrelevant. On physical examination a large globular mass about the size of a small grapefruit was palpated in the left upper abdomen. This was movable mainly from right to left. No other abnormal physical findings were present. The blood count and urine were normal.

At operation on Feb. 23, 1953, a large mass was found in the mesentery of the upper jejunum, intimately involving the mesenteric wall of the bowel at one area. It could not

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Fig. 1.—Gross appearance of the specimen showing tumor and adjacent jejunum.

Fig. 2.—Cut section of mass. This indicates the size of the tumor and shows its fibrous character.

be enucleated. The jejunum and involved mesenteric area with contained mass were resected. The proximal end of the resection was 5 cm. distal to the ligament of Treitz. Eighty-one centimeters of jejunum was excised. Side-to-side anastomosis was effected. The postoperative recovery was uncomplicated. Eighteen months postoperatively the patient was asymptomatic.

Pathology Report.—

A. *Gross findings:* The specimen consisted of a large mass to which was attached approximately 81 cm. of small intestine. At the point of attachment, the wall had been thinned out and was translucent. The mass was globular in shape and soft, with some tense areas. The mass measured approximately 19 by 15 by 12 cm. The surface was covered by a capsule which was grayish blue in color and showed numerous arborizing blood vessels. In some areas the mass appeared cystic. The mesentery of the small intestine was firmly adherent to the mass. On cross section the mass presented a homogeneous solid appearance, with areas of light yellow, pearl-white, and gray. There were several small cystic areas within, containing yellow serous fluid. The fluid was somewhat mucinous as well. When the intestinal loop was opened, a large area of complete ulceration through the loop was found, so that the capsule of the tumor formed the posterior wall of the ulcer. This ulcer extended in an area of 4 by 2½ cm.

Fig. 3.—The intimate relation of the tumor to the jejunal wall as well as its fibrous nature is seen.

B. *Microscopic findings:* The specimen consisted of a homogeneous mass of loose tissue. There was a matrix of faintly staining fibrinous tissue which contained numerous spaces where there had apparently been fluid. This tissue showed scattered capillaries with regular walls, and numerous scattered elongated or spindle-shaped nuclei, lodged in a faint cytoplasm which tapered off and merged with the general connective tissue matrix of the specimen. There was some variation in the size of these nuclei, but there was no marked difference in staining characteristics. There were no giant cells, or any local tissue change. The tumor itself was practically entirely of connective tissue origin. No definite muscle tissue was found.

C. *Diagnosis* was intramesenteric fibromyxoma, apparently of peritoneal origin. There was penetration of all layers of the wall of jejunum.

SUMMARY

A large fibromyxoma of the jejunal mesentery is presented. The presence of a large mass in the upper abdomen was the only physical finding in an otherwise symptom-free patient. Relief was effected by resection of the tumor and adjacent jejunum.

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A POLYP IN MECKEL'S DIVERTICULUM*

A Case Report

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MECKEL'S diverticulum is a rather common congenital anomaly and one of considerable surgical importance. These diverticula not infrequently contain heterotopic gastric mucosa, and hemorrhage due to peptic ulceration within the lesions is not rare. Hemorrhage without ulceration is distinctly uncommon and is usually associated with intussusception and invagination. It is the purpose of this paper to report a case of Meckel's diverticulum which contained a polyp consisting entirely of gastric mucosa and which was associated with profuse hemorrhage without ulceration, intussusception, or invagination.

This patient had severe intestinal bleeding, and his symptoms were due to such an unusual combination of lesions associated with a Meckel's diverticulum that the case is considered of such interest to warrant its report.

CASE REPORT

The patient, a 21-year-old white man, was admitted to the U. S. Naval Hospital, Portsmouth, Virginia, on March 28, 1954, with the history of having had four large, dark red bowel movements associated with nausea and intermittent crampy mid-abdominal pain during the forty-eight hours prior to admission. There had been no hematemesis or vomiting, and he had had no previous similar episodes. Careful review of the past history and systems revealed only that the patient had been on a weight reduction diet for six weeks prior to admission and that he had had an appendectomy in August, 1949.

Physical Examination.—On admission the patient had a temperature of 37.5° C. orally, pulse of 112, and a blood pressure of 126/70. He was a well-developed, well-nourished white man appearing acutely ill, pale, and restless. Examination was otherwise noncontributory except for the abdomen, which revealed intermittent tenderness to palpation in the left lower quadrant and suprapubic region. Admission laboratory studies showed a hematocrit of 21 volumes per cent with a hemoglobin of 6 Gm. per cent. The white blood count was 21,500 with a normal differential. Urinalysis was within normal limits. A transfusion of whole blood was begun which maintained the patient's vital signs to within normal levels. A sigmoidoscopy was done, and the only abnormality noted was the presence of large quantities of dark red blood arising from a site above the reaches of the sigmoidoscope. A Levin tube was passed into the stomach, and no gross blood was obtained from the gastric aspirate. Transfusions were continued to 4,000 c.c. of whole blood, and the patient's hematocrit had risen to only 26 volumes per cent. It was felt that laparotomy was indicated and this was carried out on March 29, 1954.

Operative Note.—Under general endotracheal anesthesia the abdomen was entered through a right rectus muscle-splitting incision centered at the level of the umbilicus.

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*The opinions or assertions expressed in this paper are private ones of the author and are not to be construed to be official or to reflect the views of the Navy Department or the Naval Service at large.

When the abdomen was entered, it was immediately apparent that some of the small bowel contained blood while other parts did not. Approximately two feet distal to the most proximal point where the blood was found within the lumen, a Meckel's diverticulum was discovered. This diverticulum was situated about three feet proximal to the ileocecal valve. A large nutrient artery was noted to be supplying the diverticulum. The blood supply to the diverticulum was divided between clamps and ligated. After the proximal and distal small bowel had been emptied and clamped with rubber-shod clamps, the diverticulum was removed in an oblique direction at its junction with the bowel wall. A two-layer closure of the defect in the bowel wall was then accomplished using a 00 chromic catgut Connell suture for inner layer and 0000 cotton Lembert sutures for the submucosa-serosal layer. Complete exploration of the abdomen was carried out, and no other pathology was found. The wound was closed in layers. The patient received 500 c.c. of whole blood during the procedure and was sent to the recovery room in good condition.

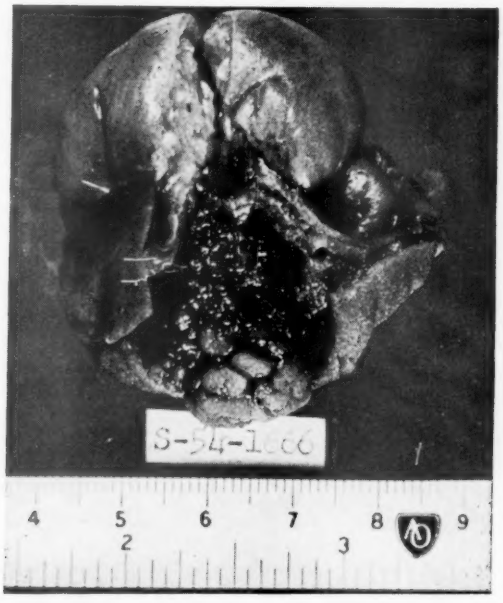

Fig. 1.—Opened Meckel's diverticulum showing polyp attached to closed end.

Pathology Report.—The specimen consisted of a pouchlike structure measuring approximately 2 cm. in length and 2 cm. in diameter. The outer surfaces were smooth and glistening, and adherent to the closed end was a mass of fat measuring 3 by 2 cm. The specimen was opened at one end and was lined by a soft, wrinkled, grayish pink, somewhat granular mucous membrane. As it was opened a polypoid structure was found to be growing from the closed end. This measured 2.5 cm. in length and approximately 1.5 cm. in diameter. It was covered by a wrinkled, grayish pink, soft, velvety mucous membrane which was thrown into numerous folds and projections to give the surface a mulberry or cauliflower appearance (Fig. 1). On sectioning, the central core was composed of a grayish white, semitranslucent, homogeneous connective tissue, and the entire mass appeared to be growing from a pedicle which measured about 1 cm. in diameter. The adjacent mucous membrane in the cross section of the wall appeared essentially normal.

Microscopic Examination.—Sections through the polyp showed it to have a central core of loose, edematous, slightly congested, fibrous connective tissue in which there were dilated lymphatic and vascular spaces. The mucous membrane was thick and polypoid in appearance, with the superficial portion composed of elongated glands lined by tall

columnar mucinous cells and the deeper portion composed of small, round glandular spaces lined by cuboidal cells having abundant eosinophilic granular cytoplasm. The structure was that of mucous membrane from the stomach. The stromal tissues were edematous and moderately infiltrated with inflammatory cells, but there was no evidence of neoplasm or ulceration (Fig. 2). At the base of the polyp the mucosa was converted into the usual type seen in the bowel wall. The connective tissues including the muscularis in all areas of the sections showed no remarkable histologic abnormality.

Pathologic diagnosis was Meckel's diverticulum containing a polyp covered by heterotopic gastric mucosa.

Following the operation the patient did well. He was discharged to duty April 20, 1954, with a healed wound. His hematocrit was 41 volumes per cent and he was asymptomatic.

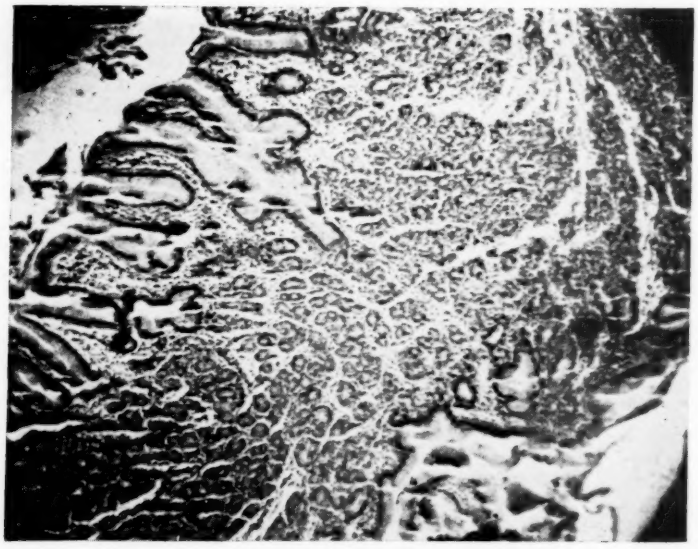

Fig. 2.—Photomicrograph of polyp in Meckel's diverticulum showing the structure to be that of gastric mucous membrane. No evidence of ulceration is seen.

DISCUSSION

Meckel's diverticulum occurs in about 2 per cent of all patients. The anomaly occurs twice as frequently in males as in females. The average age in a series of thirty-nine patients who came to surgery for this condition was 25 years. The majority of patients in this series, however, were less than 21 years old.[7]

Meckel's diverticulum gives rise to symptoms in about 25 per cent of patients with the anomaly. The symptoms are due to heterotopic gastric mucosa in 70 per cent of these.[3] In the remaining patients they are the result of pancreatic heterotopia; benign tumors including polyps, lipomas, angiomas, and myomas; malignant tumors including sarcoma, carcinoma, and carcinoid; infection; and intestinal obstruction resulting from volvulus or intussusception caused by the Meckel's diverticulum alone or in combination with the conditions mentioned.[6]

Of the 70 per cent of patients in whom heterotopic gastric mucosa in a Meckel's diverticulum is responsible for their symptoms, the symptoms most often are due to peptic ulceration of the gastric mucosa with hemorrhage or perforation.

A smaller group of these patients with gastric mucosa in a Meckel's diverticulum have bleeding without ulceration or invagination of the Meckel's diverticulum. In a series of 102 cases of hemorrhage from Meckel's diverticulum, Schullinger and Stout[6] in 1934 reported twenty-two cases of bleeding without ulceration or invagination. Of these twenty-two patients, six had bleeding from gastric mucosa without ulceration.

A review of the literature revealed only thirteen cases of a polyp occurring in Meckel's diverticulum. Bowen[2] in 1941 reported nine cases, including one of his own, of a polyp in Meckel's diverticulum, and each was associated with intussusception. Of the reported cases, only two pathology reports were available, and only one, that of Bowen,[2] was a polyp of gastric mucosa. Schullinger and Stout[6] in 1934 reported an adenoma of gastric and duodenal glands in Meckel's diverticulum associated with profuse hemorrhage without ulceration. Rowan[5] in 1926 described a papilloma with perforation of unknown cause in a Meckel's diverticulum. This was associated with attacks of bleeding per rectum. The type of mucosa was not stated. Bigelow and Clark[1] in 1950 recorded one case of polypoid folds of gastric mucosa with a nodule of pancreatic tissue in Meckel's diverticulum. This was found incidentally at the time of operation for acute appendicitis. Lindau and Wulff[4] in 1931 reported a polyp of gastric mucosa in Meckel's diverticulum with perforation of the diverticulum without bleeding.

I am unable to find in the literature another case of a polyp in Meckel's diverticulum composed of gastric mucosa only and associated with profuse hemorrhage without ulceration, intussusception, or invagination.

SUMMARY

1. A case of profuse bleeding from a polyp of Meckel's diverticulum without ulceration, intussusception, or invagination is reported. This polyp contained gastric mucosa only.

2. Meckel's diverticulum occurs in about 2 per cent of patients.

3. Meckel's diverticulum gives rise to symptoms in 25 per cent of patients with the anomaly.

4. Seventy per cent of symptomatic Meckel's diverticula contain heterotopic gastric mucosa.

5. Bleeding from heterotopic gastric mucosa in Meckel's diverticulum without ulceration or invagination is relatively rare.

6. A review of the literature revealed thirteen cases of a polyp occurring in Meckel's diverticulum.

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CHYLE PERITONITIS WITH ACUTE SMALL BOWEL OBSTRUCTION

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AN UNUSUAL finding in the peritoneal cavity associated with an acute intestinal obstruction is the presence of free chyle; this condition was recognized at operation when our patient was subjected to a celiotomy for treatment of a small bowel obstruction. In a recent review of the subject of so-called "chyle peritonitis," Hoffman[1] disclosed that only twenty-three such cases had been reported in the literature and added one case of his own. Because of the rarity of this condition, a report is presented of a similar case.

CASE REPORT

Mrs. A. S., aged 52, entered the Presbyterian Hospital on July 19, 1954, with complaints of intermittent cramping abdominal pain of two days' duration, coupled with emesis for twelve hours. The past surgical history included an appendectomy in 1927 and a surgical exploration for a bowel obstruction in 1943.

On admission the patient was experiencing cramping abdominal pain. Temperature was 98.8° F.; pulse, 92; respirations, 20. The blood pressure was 150/80. The pertinent physical findings were confined to the abdomen. A midline lower abdominal celiotomy scar was observed. There were distention and tenderness in the lower abdomen associated with muscle spasm and rebound tenderness. Bowel sounds were high pitched. A rectal examination was negative.

Laboratory data included a blood examination with a hemoglobin of 15 Gm., red blood count 4,700,000, and white blood count 14,700. The urinalysis was negative. A roentgenogram of the abdomen showed dilated loops of small bowel in the lower abdomen, suggesting an obstruction of the small bowel (Fig. 1).

At operation, through a left lower abdominal paramedian incision, a most interesting condition was found as the peritoneum was opened. A milky fluid was encountered which suggested a purulent exudate at first. A culture of this material proved to be sterile. However, on further exploration of the abdomen, it was apparent that the free fluid was chyle. Approximately 350 to 400 c.c. was aspirated. The obstructed segment of the jejunum was altered by the presence of subserosal white patches, while the adjacent edematous mesentery presented similar irregular white areas (Fig. 2). The milky white patches on the bowel and adjacent mesentery were due to dissemination of chyle through the subserosal layer of the intestine and the leaves of the mesentery, presumably the result of compression and rupture of the lacteals. The cause of the intestinal obstruction was a thin, but taut and strong, fibrous band. At this point the root of the mesentery was constricted and rotated. Simple division and resection of the band relieved the intestinal obstruction and relieved the pressure upon the lacteals of the involved mesentery. The abdomen was closed without drainage. The patient left the hospital on the eleventh postoperative day after an uncomplicated convalescence.

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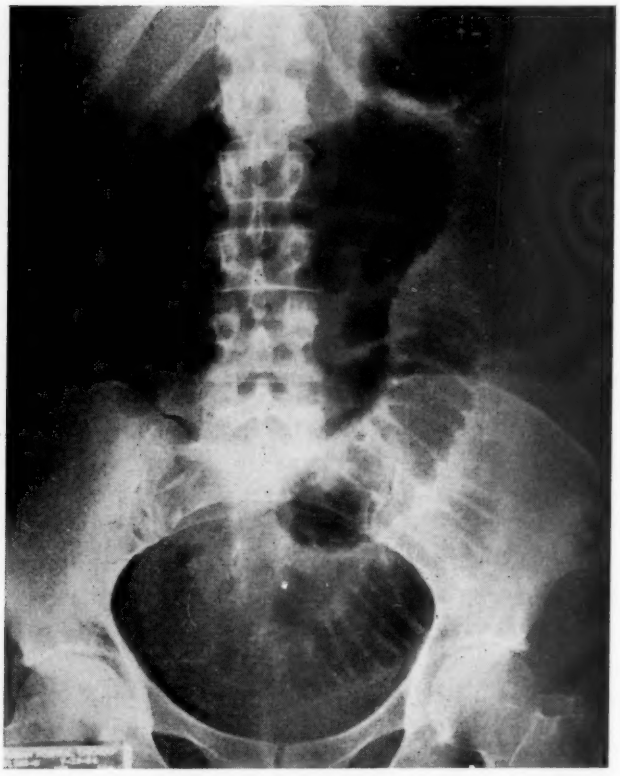

Fig. 1.—Preoperative roentgenogram showing a few dilated loops of small bowel suggesting intestinal obstruction.

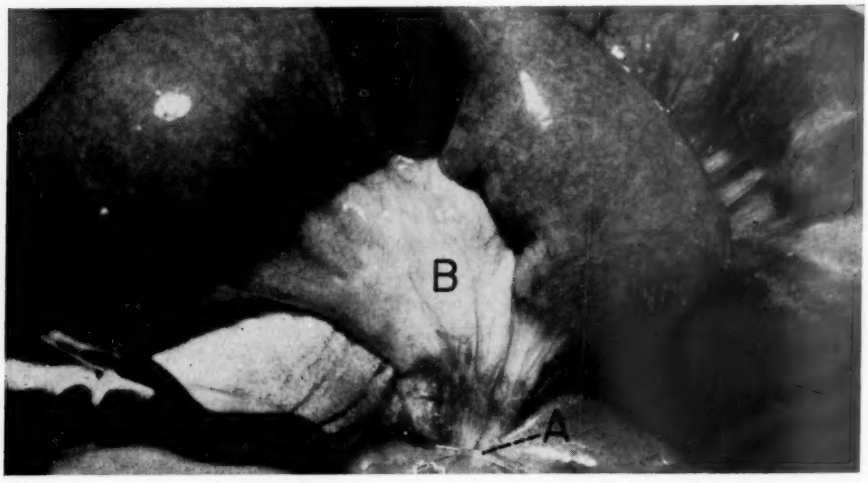

Fig. 2.—Photograph taken at operation showing the dilated and edematous segment of jejunum. Note (*A*) obstructing band and (*B*) chyle in the mesentery.

DISCUSSION

It is well known that chylous ascites may develop subsequent to traumatic or idiopathic rupture of the cisterna chyli or obstruction of the thoracic duct or the cisterna chyli; however, it is apparently unusual to find free chyle in the peritoneal cavity associated with acute abdominal pathology.

In a review of the subject of free chyle in the acute abdomen, Hoffman emphasized that in most of the cases previously reported the presence of chyle was not suspected preoperatively. The rarity of the condition is further emphasized by the fact that most of the articles in the literature contain single case reports; however, in 1939, Davis[2] presented an interesting review of the findings in three cases of chyle peritonitis, each having a different possible basis for the presence of the free chyle.

With free chyle in the abdomen and the picture of acute peritonitis, patients have been subjected to exploratory celiotomy for treatment of symptoms suggestive of acute appendicitis, acute cholecystitis, perforated peptic ulcer, mesenteric thrombosis, mesenteric lymphadenitis, and acute intestinal obstruction. The surgical conditions found at operation associated with free chyle in the peritoneal cavity include strangulated inguinal hernia; a laceration of the lower thoracic duct or cisterna chyli, secondary to traumatic injury to the abdomen; ruptured chylous mesenteric cyst; fibrous adhesions or volvulus with obstruction or incarceration of the intestine associated with secondary lymphatic obstruction. Speculation is that there is a point of obstruction to the circulation of chyle or that a weakness of the lymph vessel exists, with rupture of the lacteal.

It is suggested that chyle free in the abdominal cavity acts as an irritant, as does free blood, to produce the signs of acute peritonitis. In most instances, it is impossible to locate the break in the lacteals; consequently, surgical treatment is directed toward the removal of the offending etiological condition. Drainage of the peritoneal cavity is advocated in cases in which trauma has resulted in a laceration of the cisterna chyli or in those rare instances in which no cause is found to account for the acute peritonitis. Simple drainage apparently gives prompt and complete recovery.[3]

SUMMARY

1. A case is described of acute small bowel obstruction associated with free chyle in the peritoneal cavity.

2. Treatment consisted of freeing of a fibrous obstructing band which caused compression and rupture of the lacteals of the mesentery, spilling chyle into the peritoneal cavity.

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CARCINOMA OF CYSTIC DUCT

Case Report of a Successful Resection

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THE cystic duct is an uncommon site of origin for carcinomas of the extrahepatic bile ducts, which in turn are rarely the primary site of carcinoma, especially if the ampulla of Vater is excluded, as it has been in most reported series. The autopsy percentage has been given by Bockus[1] as 0.022 per cent, and Goldenberg[2] more recently found an autopsy percentage of 0.4 in 8,131 autopsies in New Haven. Marshall,[3] in 1932, reported finding 34 cases of carcinoma of the bile ducts in 22,000 operations on the biliary tract at the Mayo Clinic (0.15 per cent). In reviewing a ten-year experience at the Mayo Clinic, Neibling, Dockerty, and Waugh[4] reported the finding of only 66 carcinomas of the bile ducts in 14,000 operations on the biliary tract (0.47 per cent). Including autopsy material, 90 cases were accepted for study, and of these only 3 could be classified as primary in the cystic duct.

In 1940, Stewart, Leiber, and Morgan[5] reviewed 27 cases previously reported in the literature as examples of primary carcinoma of the cystic duct, but were unable to consider any of these as indisputable instances of primary carcinoma of the cystic duct. They concluded that, "No proved case has yet been reported of a malignant growth arising primarily in the cystic duct and remaining sufficiently localized within the confines of that structure to make the origin of the tumor unquestionable." Since that time, 6 acceptable case reports of primary carcinoma of the cystic duct have been found in the literature. These were reported by Brunschwig and Clark[6] in 1941, Weimershaus[7] in 1941, Oppenheimer[8] in 1942, Ciocatto[9] in 1945, Farrar[10] in 1951, Redmon and Majeranowski[11] in 1954. The last case was discovered at autopsy after the patient had died of carcinomatosis. The other patients were all operated on, and the operative findings have been diagramed by Farrar[10] in reporting his case. His patient was living six months after resection without evidence of recurrence. Brunschwig and Clark[6] had to remove a portion of the hepatic artery in performing their resection and their patient died twenty-two days later. Oppenheimer's[8] patient had metastases in two lymph nodes adjacent to the common duct, and although these were removed at the time the primary tumor was removed, the patient died eleven months postoperatively. In addition to these 6 case reports, Neibling, Dockerty, and Waugh[4] classified 3 of their 90 cases as being primary in the cystic duct, and in 1953 Glenn and

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Hays,[12] in reporting on a twenty-year experience at the New York Hospital, found 3 cases of cancer of the cystic duct. Case histories are not given for any of the 6 cases in these two papers.

CASE REPORT

W. H., a 78-year-old Negro veteran of World War I and a retired Pullman porter, was admitted on July 25, 1954, with the chief complaint of pain in the epigastrium and right lower quadrant beginning two and one-half hours before admission. Nausea and vomiting occurred thirty minutes later. The patient had been remarkably free from any previous gastrointestinal complaints, and his general health had been exceptionally good all his life. A hemorrhoidectomy had been performed in 1898, and in this hospital, in 1951, a right inguinal herniorrhaphy was performed for an incarcerated, indirect hernia. In 1952 and in 1954, transurethral prostatic resections were carried out for a benign hypertrophy. On these admissions, a medical diagnosis of arteriosclerotic heart disease with hypertension, Class II, had been made.

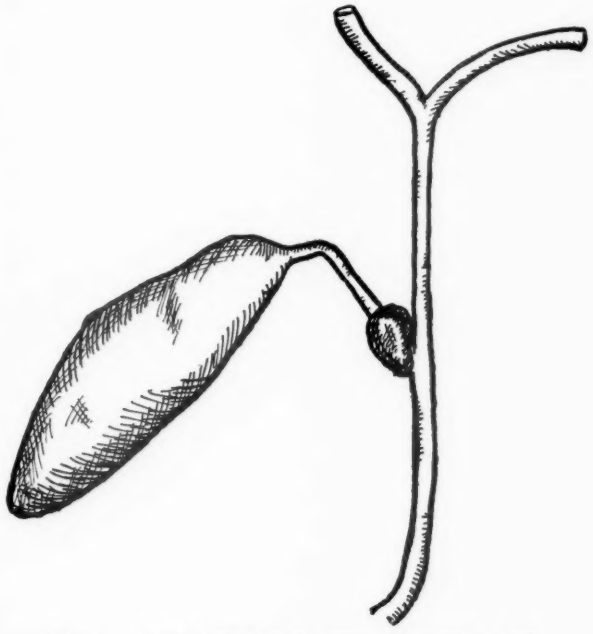

Fig. 1.—Line drawing of tumor of cystic duct.

Physical examination revealed a well-developed and well-nourished Negro man who appeared younger than his 78 years, and did not appear seriously ill. Blood pressure was 130/88. The heart was enlarged to the left and occasional extrasystoles were heard. There were well-healed surgical scars in the right lower quadrant, one paramedian and the other parallel to the inguinal ligament. The abdomen was flat and soft with some tenderness in the epigastrium, but no masses were felt.

The routine laboratory findings were not remarkable. The Venereal Disease Research Laboratory test was positive in two dilutions, but the spinal fluid examination was negative. The nonprotein nitrogen was 49 mg. per cent two days after admission and 44 mg. per cent three weeks later. The electrocardiogram showed a normal sinus rhythm compared to the auricular fibrillation present on the tracing of Jan. 4, 1954. T-wave changes were improved as compared to the previous electrocardiogram, but were considered indicative of myocardial change. A roentgenogram of the chest showed no change from previous examinations in this hospital regarding the left ventricular hypertrophy, thoracic

arteriosclerosis, moderate pulmonary emphysema, and fibrosis. An upper gastrointestinal series and barium enema were normal. A gall-bladder series showed nonfunctioning of the gall bladder, and a calcific density was described in the gall-bladder area.

The patient's initial severe abdominal pains subsided within five hours after sedation, following which he remained asymptomatic until August 12, at which time he had another episode of pain in the right upper quadrant. This attack was again very severe, but subsided without medication. When the aforementioned studies had been completed, surgical

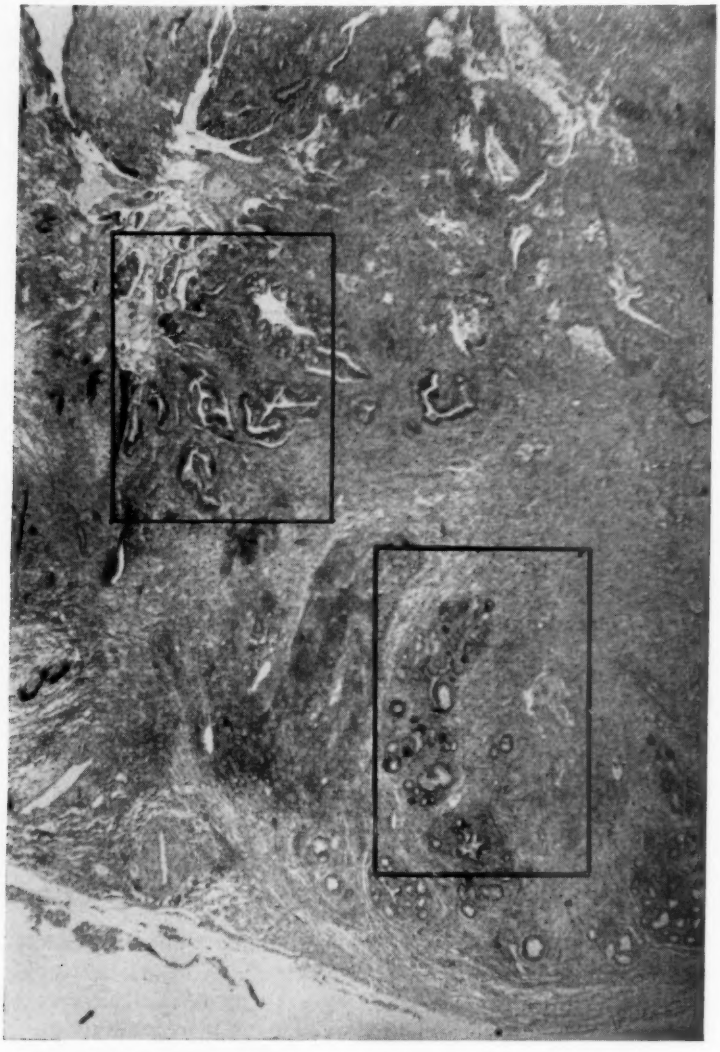

Fig. 2.—Photomicrograph of tumor (×60; reduced ¼).

consultation was requested. Cholecystectomy was advised and surgical treatment accepted by the patient after frank discussion with him of the risks involved and probable course without surgery. He had a third bout of abdominal pain on the morning of August 26, a few minutes before his operation.

At operation, adhesions were found in the region of the right paramedian scar in the lower quadrant and a few adhesions also between the gall bladder and duodenum. The gall bladder was markedly elongated and almost tubular. It was soft, without palpable stones, and practically empty except for a small amount of mucus. There was a long and

somewhat tortuous cystic duct which entered the common duct obliquely. The first 3 cm. of the cystic duct was normal, but there was a tumefaction involving the distal 1.5 cm. of the duct, which was quite firm, about 1.5 cm. in diameter, and at first was thought to represent an impacted stone with surrounding inflammation. However, on opening this portion of the cystic duct, it was found that the enlargement was due to thickening of its walls, the inner aspect of which was gray, roughened, and indurated. A frozen section of this portion of the cystic duct showed adenocarcinoma. After the gall bladder was removed, the common duct and common hepatic duct were freed from the hepatic artery and portal vein. The common duct was not enlarged and contained normal-appearing, clear bile. Since the tumor of the cystic duct was adherent to the outer wall of the common duct, about 1.5 cm. of this structure and a similar amount of the common hepatic duct were

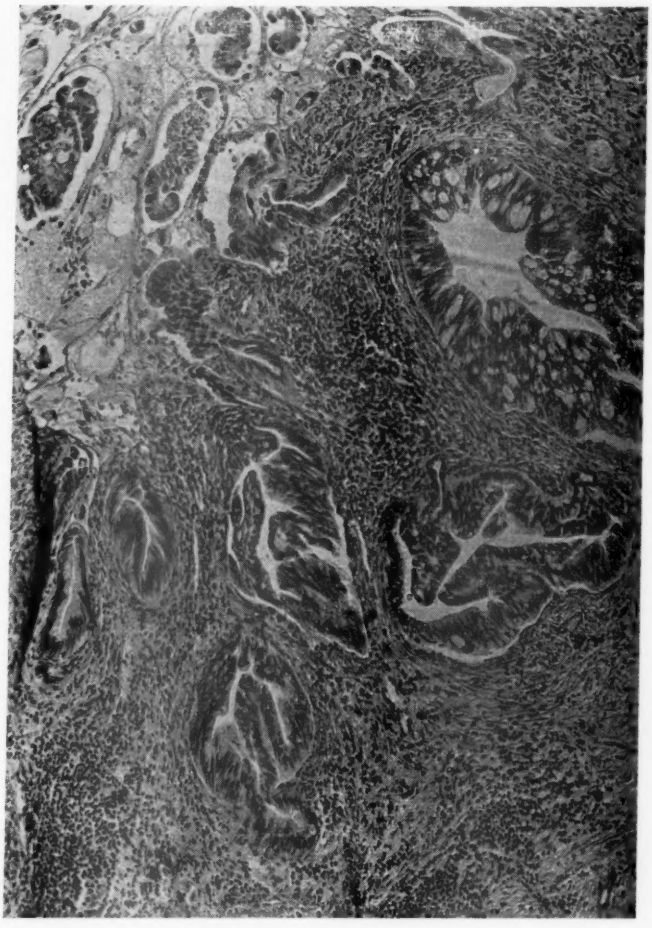

Fig. 3.—Photomicrograph (×200; reduced ⅓) of field in upper left rectangle of Fig. 2.

resected. An end-to-end anastomosis was not possible without undue tension, and therefore the common hepatic duct was anastomosed to the mobilized duodenum without use of a splinting catheter. Morison's pouch and the gall-bladder bed were both drained through a stab wound. The patient received 500 c.c. of blood during the operation, which he withstood well. He made an uneventful recovery, and was discharged on his fourteenth postoperative day. The patient was seen on routine checkup on Dec. 9, 1954, at which time he had had no recurrence of abdominal pain or other complaints. Appetite was good; bowel movements normal. There were no abdominal masses and no jaundice.

Microscopically, the tumor was a moderately well-differentiated adenocarcinoma with marked fibrosis and chronic inflammatory cells seen in the tissue surrounding the tumor. A few irregular glands with malignant cells were seen in that portion of the wall of the common duct immediately adjacent to the tumor. The gall bladder and proximal portion of the cystic duct showed no evidence of tumor.

Fig. 4.—Photomicrograph (×200; reduced ⅓) of field in lower right rectangle of Fig. 2.

DISCUSSION

This case is similar to the other six case reports of proved primary carcinoma of the cystic duct in that in each case the tumor was in the distal end of the duct in close proximity to the hepatic and common ducts. In the cases reported by Brunschwig and Clark[6] and Oppenheimer,[8] the tumor actually encroached upon the lumen of the common duct, with the result that jaundice was the presenting symptom in these cases. Our case was most similar to that of Farrar's[10] in that there was no obstruction of the common duct and the only symptoms were colicky pain in the right hypochondrium of short duration, nausea, and vomiting. All authorities are unanimous in the opinion that the preoperative diagnosis of carcinoma of the extrahepatic bile ducts cannot be made until the signs and

symptoms of obstructive jaundice are present, and even then the most common preoperative diagnosis will be carcinoma of the head of the pancreas or the ampulla of Vater.

The average age of patients with these tumors is from 50 to 70 years, and, in contrast to carcinoma of the gall bladder, there is a slight predominance of males. Associated stones in the ducts or gall bladder are present in only about one-third of the cases. Pathologically, these tumors are almost invariably adenocarcinoma and have been classified as either villous nodular or diffuse in type. The nodular or annular form is by far the most common. Apparently these tumors metastasize late and infrequently, and failure to obtain cures results from the invasion of the vital structures which lie in close proximity. Where possible, resection of the involved portion of duct has given the best results, but the Whipple operation or one of its modifications may have to be performed for the lower end of the common duct. When end-to-end anastomosis cannot be carried out for the reconstruction, the impression at the Mayo Clinic,[4] based on their own and other series, is that the Roux type of anastomosis is neither necessary nor desirable for reimplantation of the hepatic or common duct. No long-term cures have been reported. None of the three patients mentioned by Neibling, Dockerty, and Waugh[4] survived over twenty months. Farrar's[10] patient was living without sign of recurrence at six months.

SUMMARY

1. A case of primary carcinoma of the cystic duct successfully resected is reported.

2. The recent literature on this subject has been briefly reviewed. This case represents the seventh proved case of carcinoma of the cystic duct to be reported in detail, although six others have been mentioned in papers reviewing the subject of carcinoma of the extrahepatic bile ducts.

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POPLITEAL EMBOLECTOMY CARRIED OUT BEFORE AND ALSO AFTER MITRAL COMMISSUROTOMY

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INTRODUCTION

PERIPHERAL embolization has always been considered a serious complication of mitral stenosis.[1] With the development of mitral commissurotomy the further danger of arterial embolization during intracardiac manipulation has been introduced.[2] This case is reported to demonstrate successive and successful bilateral embolectomy in a patient who developed occlusion of one popliteal artery before commissurotomy and occlusion of the other popliteal artery after commissurotomy.

CASE REPORT

A 56-year-old white man was admitted to Mount Sinai Hospital approximately nine hours after the sudden onset of pain and numbness in the left leg. He had a history of rheumatic fever as a child. There were no cardiac symptoms until four years prior to this admission, at which time the patient first experienced paroxysmal auricular fibrillation. Since that time he had maintained a regular sinus rhythm on digitalis and quinidine. The quinidine was discontinued a few months prior to admission. Four days prior to admission, auricular fibrillation recurred, associated with severe weakness and shortness of breath. He was admitted to another hospital. Digitalis was maintained and quinidine was given in progressively increasing doses until, on the morning of admission, he converted to regular sinus rhythm. Soon thereafter, the patient experienced pain and numbness in the left leg. A diagnosis of popliteal embolism was made and the patient was transferred to Mount Sinai Hospital for operation.

On admission, the patient appeared apprehensive and seriously ill. The blood pressure was 98/68. There was a regular sinus rhythm with a heart rate of 60 per minute. The chest was emphysematous and the heart sounds were poorly heard. In the left lateral position, an accentuated mitral first sound could be heard, followed by a Grade II systolic murmur. A faint crescendo diastolic murmur was heard in a small area just over the apex. Arterial pulsations were present in the upper extremities and in both femoral arteries. The left leg was pale and cool from the knee down. No pulsations could be felt in the left popliteal, posterior tibial, or dorsalis pedis arteries.

Emergency operation was performed.* Under spinal anesthesia, the patient was placed in the prone position. A small pillow was placed under the ankle to relax the hamstring muscles. The popliteal artery pulsated feebly. Approximately 3 cm. was dissected out without sacrificing any branches. A Potts clamp was placed on this artery and it was incised longitudinally for 1 cm. A small amount of red blood came from the distal end of the artery. Polyethylene tubing with a 3 mm. bore was then introduced into the distal end. Repeated suction for a distance of about 15 cm. produced six cylindrical pieces of clot. The artery was sutured with everting continuous suture. When the

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*By Dr. Claude S. Beck.

clamp was removed the dorsalis pedis and posterior tibial pulsations immediately returned. The wound was then closed with fine silk. In the days following this operation, normal function was restored to the left leg.

Five days following embolectomy, mitral commissurotomy was performed. When the pericardium was opened, a localized diastolic thrill was felt at the apex. When the finger was introduced into the left auricle, slight mitral regurgitation was noted. No clots were present. The posterior commissure was heavily calcified and calcium protruded from the valve. The anterior portion was not calcified. The valve orifice was elongated and measured 1 cm. in diameter. Manual compression of the carotid arteries was provided by the anesthesiologist while the valve was carefully opened by finger-fracture. Using the tape-wrapped finger,[3] the orifice was opened to a diameter of 2.5 cm. The anterior commissure opened out to muscle. The diastolic thrill disappeared completely and there appeared to be some reduction in the degree of mitral insufficiency. The base of the auricular appendage was then ligated, the appendage amputated, and the chest was closed.

Immediately after surgery, normal pulsations were present peripherally. Two hours after the patient reached the recovery room, the right leg was noted to be pale and cool. Dorsalis pedis and posterior tibial pulsations were absent. Lumbar paravertebral block was performed without improvement. Right popliteal embolectomy was then performed in a manner similar to that performed on the left five days previously. This was followed by return of normal pulsations in the right leg. Regular sinus rhythm had been maintained throughout.

The patient's hospital course thereafter was relatively uneventful. He was discharged greatly improved, thirteen days after the mitral commissurotomy, eighteen days after admission. One month later, he was back at full-time work, having maintained marked clinical improvement.

DISCUSSION

The embolic episodes occurring in this patient demonstrate two different methods by which this complication may occur. In mitral stenosis, the occurrence of mural thrombosis in the left auricle appears to be somewhat more frequent in the presence of auricular fibrillation, although quite common in patients with regular sinus rhythm. Sudden dislodgment and peripheral embolization may occur at any time. The persistence of auricular fibrillation predisposes to formation of thrombi, so that the maintenance of regular sinus rhythm is desirable. However, once auricular fibrillation occurs, conversion to regular sinus rhythm carries with it the implied danger of dislodgment of an atrial mural thrombus following resumption of effective atrial contractions. Although generally it appears desirable to achieve a regular sinus rhythm whenever possible, we believe the first embolic episode in this case must be considered as related to this conversion. Perhaps anticoagulant therapy for one to two weeks before conversion would have prevented embolization.

The second occlusion, following mitral commissurotomy, is considered a complication of the operation. During introduction of the finger into the left atrium, unsuspected emboli may be dislodged. These emboli may be dislodged from the valve leaflets. Calcium deposits on the valve may be broken off during finger-fracture and liberated into the arterial circulation.

Sudden occlusion of the popliteal artery by an embolus is characterized usually by severe pain in the leg. There is a fall in the skin temperature. The extremity is pale at first but may return to normal color within a few

days if adequate collateral circulation develops. As a rule, the extremity continues to be pale with increasing patchy, dusky cyanosis. The superficial veins appear collapsed. The posterior tibial and dorsalis pedis pulses are absent. Numbness and tingling, loss of strength, or paralysis of the leg may develop. If no treatment is carried out the following train of events may occur: vasospasm, ischemia, intermittent claudication, venous thrombosis, gangrene. A late development in limbs that survive may be ischemic neuritis.

Peripheral arterial emboli carry a relatively high morbidity and mortality. McClure and Harkins[4] reported a mortality rate of 40 to 59.4 per cent and amputation because of resulting gangrene in 18 to 22 per cent. The very serious nature of peripheral arterial embolism has been stressed also by Andrus.[5] Usually acute occlusion of the popliteal artery by an embolus occurs at the bifurcation and distal to the origin of collateral branches. In spite of the relatively favorable position of the embolus, at least seven out of thirty-three patients treated conservatively by Warren[6] lost their limbs.

Because of the relative simplicity of the surgical procedure and the uncertainty of conservative therapy, it is felt that popliteal embolectomy is the treatment of choice. In general, operation is carried out in the following manner:

Under long-acting spinal anesthesia the patient is placed in the prone position. A small pillow is placed under the ankle causing flexion of the knee, thus relaxing the hamstring and calf muscles. The incision is about 5 inches in length and lies in the midline of the limb and should extend distally from the lower one-fourth of the thigh. The small saphenous vein and sural nerve are retracted at the lower half of the wound and the deep fascia of the popliteal space exposed and incised. The two heads of the gastrocnemius muscle are separated below, and the semimembranosus is separated from the biceps at the upper part of the space. The popliteal artery, vein, and tibial nerve can be found in this area surrounded by fat and connective tissue. The tibial nerve lies immediately behind the popliteal vessels in the middle of the popliteal space. At the upper end of the space the vessels are medial to the nerve. At the lower end of the space the vasculonervous bundle disappears under the fibrous arch of the soleus muscle. To expose the bifurcation of the popliteal artery, the soleus may be split vertically, nearer the tibia than the fibula, so that the nerve supply to the muscle is not damaged. The popliteal artery is mobilized by gentle sharp dissection. The site of obstruction can be identified by absence of pulsations. The proximal end of the artery is temporarily occluded by an artery clamp or an umbilical tape. A small vertical incision is made over the embolus and the clot is removed by forceps extraction, strong suction, or milking. If the site of obstruction cannot be identified, a large lumen polyethylene catheter is inserted through a small incision in the popliteal artery and directed distally. By strong suction applied to the catheter the clot may be removed. The incision in the artery is closed with No. 5 silk.

To improve the circulation in the extremity, auxiliary methods are applied. The head of the bed is elevated so that the leg is lower than the heart level, for gravity aids the flow of blood down the collateral channels. The limb should be kept warm by wrapping it loosely in a layer of cotton wadding. However, the temperature around the limb should not exceed 92° F. Heat should not be applied directly to the part. The extremity should be protected against injury and pressure. Infection can be prevented by the use of antibiotics. Paravertebral sympathetic nerve block may be employed after the effect of the spinal anesthetic wears off.

COMMENT AND SUMMARY

In so far as we can ascertain, this case is unique in the localization of embolization, the mode of production of the emboli, and the successful treatment thereof. Vascular surgery appears to be much more effective than "conservative" treatment. We would agree with Pemberton, who stated in 1928, "There is no established operative procedure of equal simplicity, fraught with so little risk and with such dramatic potentialities, that has been so woefully neglected as embolectomy for circulatory disturbances of the extremities."

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THYMOLIPOMA

Report of a Case

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RECENTLY Rubin and Mishkin[7] wrote an interesting report on "The Relationship Between Mediastinal Lipomas and the Thymus." In the literature they had been able to find three reported cases[1, 2, 4] of benign mediastinal tumors consisting of an admixture of thymic and fatty tissue. They remarked on a possible fourth case, reported by Bariety and Coury,[2] but the paper was not available to them. We have been able to review this paper, which reported a 40-year-old white woman who was subjected to a right thoracotomy for removal of a mediastinal tumor. The pathologic diagnosis was benign lipothymoma, and the described tumor appeared to be identical with the other tumors discussed herein.

We have been able to find two additional cases in the literature. Hall[5] reported on a 47-year-old man who was killed in an accident. Autopsy revealed the presence of a mediastinal tumor containing both thymic and fatty elements, and to the tumor he gave the name "thymolipoma." Schanher and Hodge[8] reported on a 35-year-old woman who was subjected to exploratory thoracotomy because of dyspnea, orthopnea, cough, and wheezing, with roentgenographic evidence of a mediastinal tumor. Roentgenographic examination ten years before probably had revealed the same tumor, although at that time the diagnosis had been "enlarged right side of the heart." A tumor weighing 625 grams was removed at operation, and "microscopic examination showed a typical lipoma and in the more central portion of the tumor remnants of fibrotic thymus tissue were found."

CASE REPORT

To the seven cases that we have been able to find in the literature, we would like to add one case. J. D. J., a 22-year-old white man, was admitted to Lawson Veterans Administration Hospital on Aug. 24, 1950. About one year before admission he had had a roentgenogram of his chest taken in connection with his occupation, and he was informed that he had a collapsed right lower lobe. At this time the patient was asymptomatic. Three months later he noted mild pain in the right lower chest, and he sought admission at Dublin Veterans Administration Hospital, where roentgenograms revealed an intrathoracic mass for the treatment of which the patient was transferred to Lawson Veterans Administration Hospital. On admission he stated that he had lost 20 pounds in the previous six months. He had a mild nonproductive cough. He denied chest pain. System review and past medical history were otherwise noncontributory.

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Physical examination was within normal limits, and blood and urine studies were not noteworthy. Roentgenographic study (Fig. 1) revealed a lobulated mass in the right cardiophrenic angle, and further study revealed it to lie anteriorly. A diagnostic pneumothorax showed the mass to be distinct from lung substance and from diaphragm.

A chest roentgenogram made in 1945, while the patient was in the Navy, revealed no evidence of mediastinal tumor.

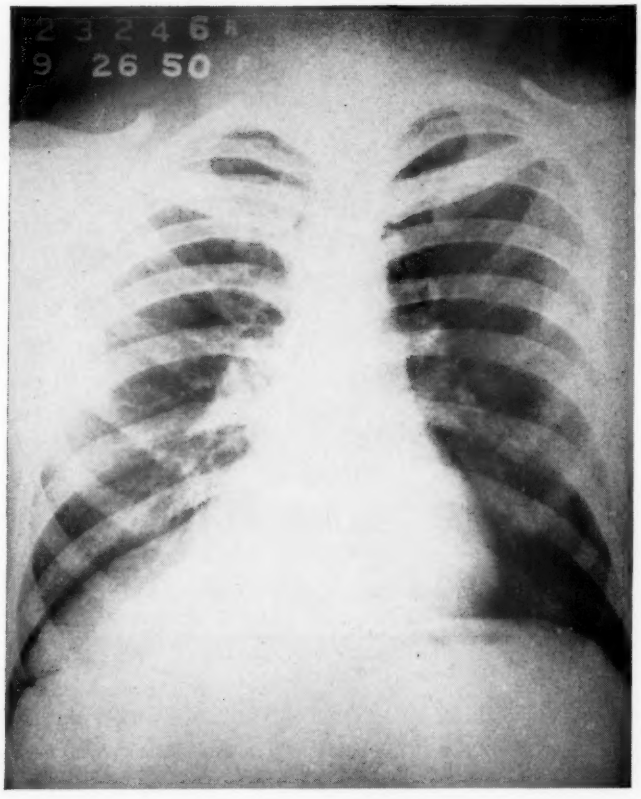

Fig. 1.—Preoperative roentgenogram demonstrating lesion.

A diagnosis of probable mediastinal lipoma was made, and surgical removal recommended. On Nov. 1, 1950, a right exploratory thoracotomy was performed. Grossly, the mass was found to be yellow in color and soft in consistency, and it was thought to be a lipoma. The pedicle entered the mediastinum at the level of the superior pulmonary vein. Extirpation of the mass was achieved without difficulty, and the patient's postoperative recovery was uneventful. He was discharged on Nov. 15, 1950. A chest roentgenogram dated April 15, 1954, revealed no evidence of recurrence of the tumor. The patient was asymptomatic.

Fig. 2 shows the gross appearance of the lesion after excision. The soft, slightly nodular mass of tissue measured 20 by 15 by 4 cm., and weighed 540 grams. The surface was smooth and gray-pink, and small blood vessels could be seen coursing through the thin connective tissue capsule. The cut surface was light gray-yellow, and scattered indiscriminately through the mass were irregular islands of lighter gray-pink tissue which were responsible for the nodularity. Histologically, the fat cells were normal in appearance and their nuclei not appreciably pleomorphic. Scattered throughout the fat in numerous sections were irregular islands of thymic tissue composed of lymphoid elements containing typical Hassall's

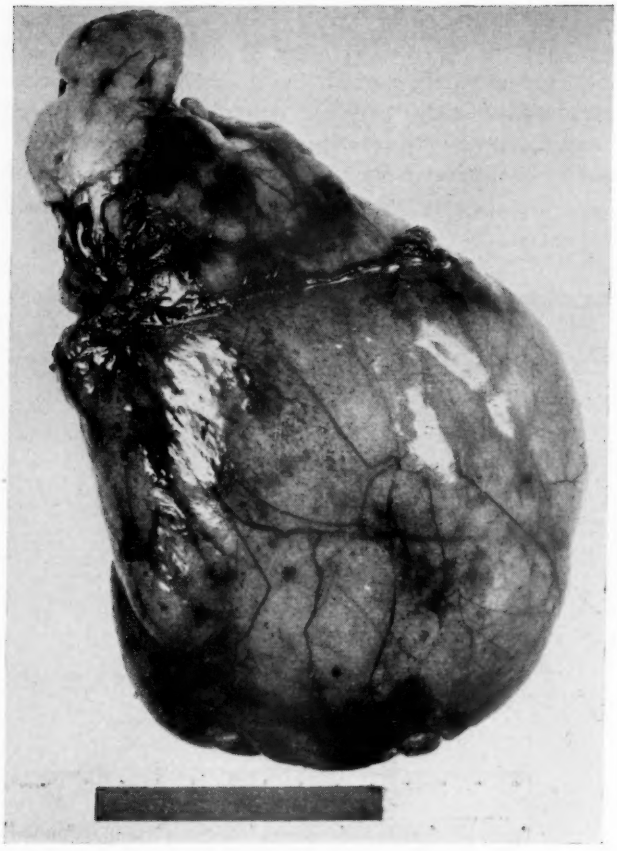

Fig. 2.—Gross appearance of the surgical specimen.

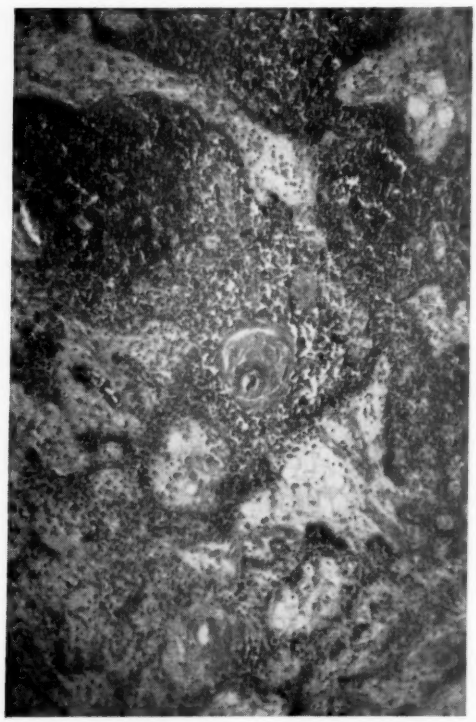

Fig. 3.—Photomicrograph of the surgical specimen.

corpuscles. The follicular architecture of the lymphoid tissue was well preserved and the individual cells showed no evidence of neoplasia (Fig. 3). The pathologic diagnosis was thymolipoma.

SUMMARY AND CONCLUSIONS

Eight patients (including the one described in this report) presenting mediastinal tumors composed of both thymic and fatty tissue are now recorded in the literature. The mediastinal lesions have been variously designated "mediastinal lipoma with inclusion of remnants of thymus gland,"[8] "thymolipoma,"[5] "benign thymoma,"[6] and "lipothymoma."[3] In one patient there was some question of malignancy because of the presence of mitoses in several islands of "thymoid" tissue. Gross[4] felt that he could not make a positive statement concerning the ultimate prognosis for the child upon whom he operated.

Hall, in discussing the possible etiology of these tumors, commented on the fact that while fat is mesodermal in origin, the thymus is entodermal in origin, and he inclined to the belief that these are true mixed tumors with proliferation of both fatty and thymic elements. It was Hall who first suggested the designation "thymolipoma." Rubin and Mishkin suggested that these mediastinal tumors might result from involution of the thymic elements with continued growth of the fatty elements of the tumor.

The eight patients in whom the described lesion has been discovered include four children, aged 10, 13, 14, and 19 years, respectively, and four adults, aged 22, 35, 40, and 47 years, respectively.

We are inclined to accept Hall's theory as to the etiology of these tumors, and to accept his terminology of "thymolipoma" as meaning a benign mediastinal tumor composed of both thymic and fatty elements.

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PRIMARY LEIOMYOSARCOMA OF THE FEMORAL VEIN

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(From The Surgical Clinic)

ALTHOUGH leiomyosarcomas occasionally arise from the gastrointestinal and genitourinary systems, they rarely originate in the cardiovascular system. Meager information makes it difficult to accept many of the reported cases as being primary intrinsic tumors of blood vessels. The obvious error of ascribing a vascular origin to a tumor solely on the proximity of a large vessel coursing near or through it must be avoided.

There are several authenticated cases of leiomyosarcoma arising from the heart,[2] inferior vena cava,[1, 3, 5, 6, 8, 9] femoral,[4] and left colic veins.[7] Perl in 1871 reported the first primary tumor of a blood vessel (inferior vena cava). The tumor, classified as a myosarcoma by Virchow, produced caval obstruction with edema of the lower extremities, ascites, and dilated superficial veins. Unruh in 1896 reported a 1-year-old with an endothelioma of the inferior vena cava producing progressive edema. Melchior (1928) reported a fibrosarcoma of the inferior vena cava removed surgically, with the patient dying subsequently of gangrene of the lung.

Hallock (1940) and associates reported a leiomyosarcoma occluding the subdiaphragmatic inferior vena cava with an extension into the right hepatic vein. The clinical picture was suggestive of Chiari's disease with hepatomegaly and rapidly reaccumulating ascites. Roussak and Heppleston (1950) cited an autopsied case of leiomyosarcoma of the inferior vena cava. Cope and Hunt (1954) reported the first successfully excised leiomyosarcoma of the inferior vena cava. The tumor recurred locally sixteen months later.

Haug and Losli[4] recently reported a case of primary intraluminal leiomyosarcoma of the femoral vein, apparently arising from a valve cusp. Initial symptomatology was limited to intermittent swelling of the right leg with subsequent development of a firm, fixed mass in the right groin. Despite a hemipelvectomy, the patient expired two and one-half years later of massive metastatic spread to the lungs. Puig-Sureda and co-workers reported a leiomyosarcoma arising from the left inferior colic vein presenting as a movable, painful mass in the left lower quadrant. This was successfully excised and the patient was well five months later.

It is of particular interest that in two of the recorded cases of primary leiomyosarcoma arising from blood vessels[4, 8] there was localized Paget's disease in the pelvis presenting as an osteoblastic lesion in both with elevated serum alkaline phosphatase in one.

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CASE REPORT

Mrs. M. S., a 67-year-old white woman, noted a mass in the right groin while bathing in April, 1954. There was no pain, discomfort, or systemic reaction. The pertinent physical findings were limited to the right femoral region, where a 6 by 7 cm. firm mass, lying medial to the femoral artery and apparently attached to the underlying structures, was found. The mass extended from the inguinal fold toward the apex of Scarpa's triangle. There was no inguinal or generalized lymphadenopathy. Bilateral Grade I superficial varicosities were evident; there was no edema. Pelvic and rectal examinations were negative.

Laboratory data were nonrevealing. Roentgenologic examination of the chest and gastrointestinal tract was entirely negative except for a few sigmoid diverticuli.

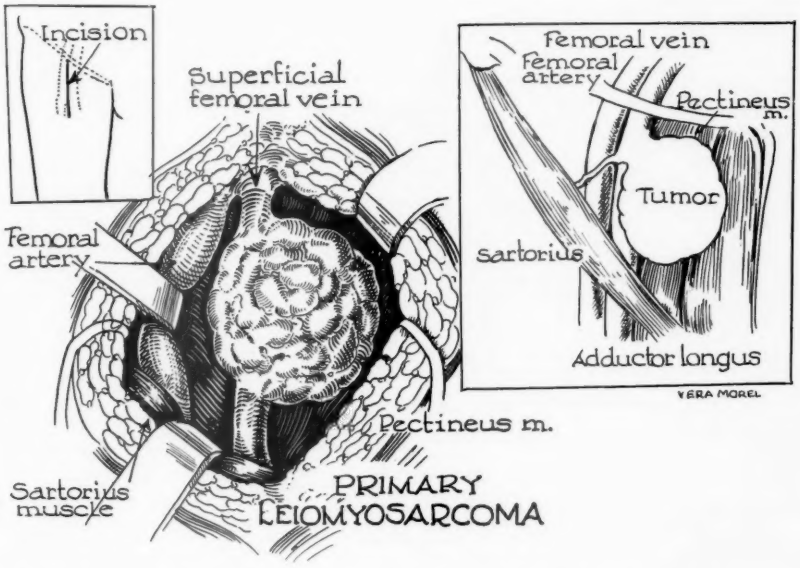


Fig. 1.—Artist's diagram depicting location and gross characteristics of primary leiomyosarcoma of femoral vein.

With a preoperative diagnosis of probable sarcoma arising in soft parts, surgical exploration of the mass through a longitudinal incision extending distally from the inguinal ligament, medial to the femoral artery pulsations, was carried out (Fig. 1). A firm, grayish white, lobulated mass, 8 cm. in diameter, arising from the right superficial femoral vein presented. The tumor was easily freed from the adjacent muuscles: sartorius, adductors, and pectineus. The mass was an integral part of the superficial femoral vein and could be removed only by sacrificing a 4 cm. segment of this vessel. Postoperative convalescence was entirely smooth except for minimal swelling of the right lower extremity, which has decreased with the use of elastic stockings.

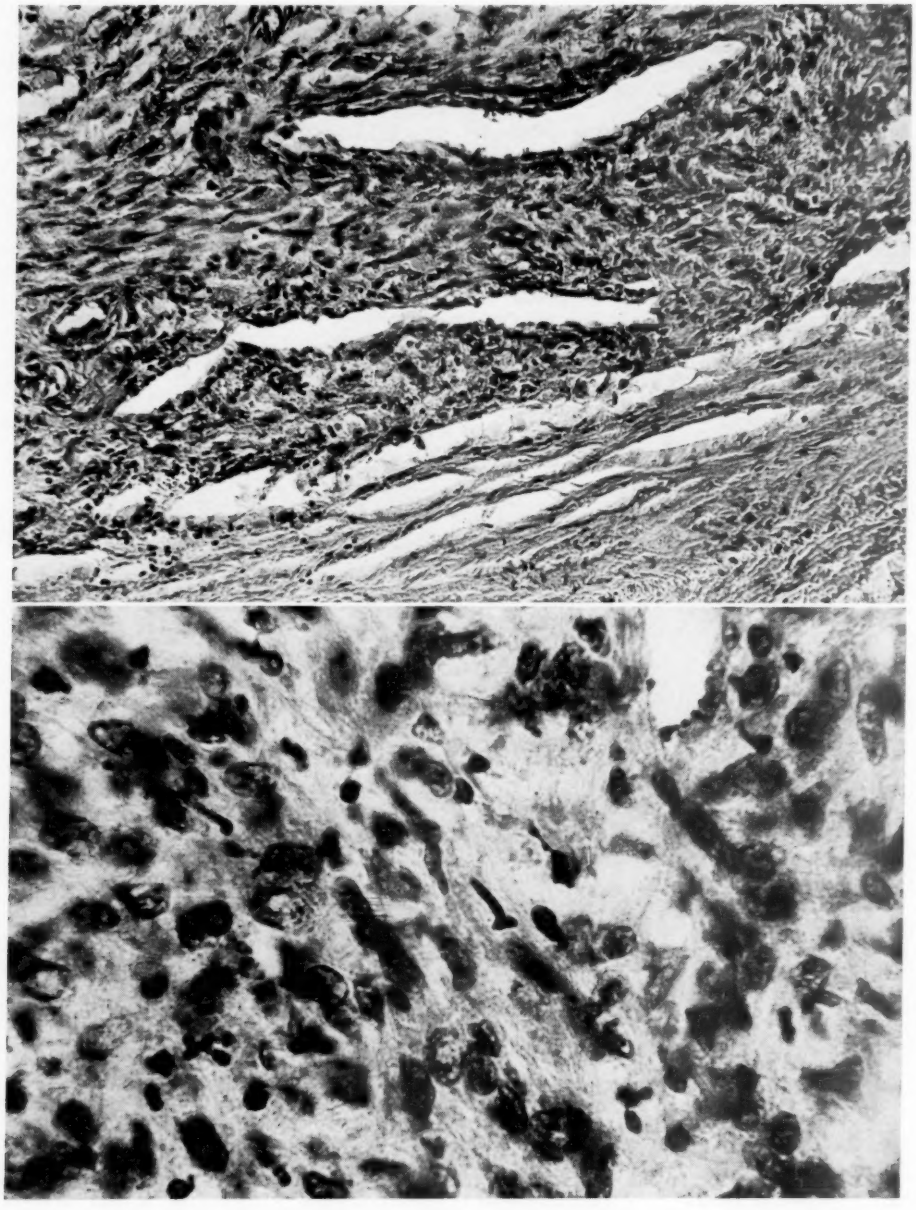
*Pathology Report.**—The specimen consisted of a poorly encapsulated, grayish white mass measuring 8 by 6 by 7 cm., firmly attached to and apparently arising from the large vein. Microscopically, it was composed of spindle-shaped cells having a whorled and interlacing pattern (Fig. 2). The cell boundaries were indistinct and the cytoplasm sparse. Nuclei showed marked variation in size and shape with many giant hyperchromatic nuclei. A moderate number of cells in the process of mitotic division could be seen. Focal areas of

*By Dr. F. G. Bratley.

necrosis and degeneration were present in some areas of the tumor. One artery was present along one margin of the specimen and showed moderate calcification. The superficial femoral vein was completely occluded by neoplasm.

Diagnosis was leiomyosarcoma, apparently arising in the right superficial femoral vein.

A.



B.

Fig. 2.—*A*, Photomicrograph showing leiomyosarcoma arising from wall of large vein. *B*, Higher magnification showing indistinct cell boundaries with marked nuclear pleomorphism.

Postoperatively the patient received 2,000 roentgens in air over a field of the lower abdomen and right upper thigh measuring 10 by 15 cm. in ten days. During the nine-month period of follow-up, there has been no evidence of local or distant recurrence.

SUMMARY

The second case of leiomyosarcoma of the femoral vein is recorded. Primary tumors of blood vessels are extreme rarities. The majority of these are leiomysarcomas; less frequently, the microscopic picture is that of endothelioma or fibrosarcoma.

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Recent Advances in Surgery

CONDUCTED BY ALFRED BLALOCK, M.D.

DELAYED RUPTURE OF THE SPLEEN AFTER TRAUMA

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DELAYED or secondary rupture of the spleen following trauma is an unusual clinical entity, but it is not as rare as is generally believed. Immediate splenic rupture is much more common, occurring about six times more frequently than delayed rupture.[1] McIndoe,[2] the first to make an intensive survey of this problem, set forth the criteria for the diagnosis of delayed rupture which are still accepted. The two conditions which must follow the original injury are a latent period of forty-eight hours or more without symptoms and the sudden onset of the symptoms of intraperitoneal hemorrhage occurring thereafter. McIndoe collected a total of forty-six cases, including one case of his own. Zabinski and Harkins[5] accumulated 472 cases, including the one reported by McIndoe and four cases of their own. Since 1943, only thirty-four cases have been reported in the American literature.

The possibility of delayed splenic rupture must be kept in mind in all patients who have sustained direct or indirect trauma to the lower chest, upper abdomen, or back on the left side. The diagnosis can be made only by keeping the possibility of this complication in mind and by knowledge of the signs and symptoms of delayed rupture. The condition has frequently been confused with appendicitis, ectopic pregnancy, cholecystitis, ruptured ulcer, pneumonia, pancreatitis, rib fractures, and pulmonary embolism.[3]

Our experience with fifteen cases of delayed rupture of the spleen during the past fourteen years represents the largest individual series recorded, and is the basis of this report.

MATERIAL

Between Jan. 1, 1940, and Jan. 15, 1954, fifteen patients with this condition have been studied, seven cases from Cincinnati General Hospital and the remaining eight from private practice (Table I).

The ages of the patients varied from 11 to 62 years, the average being 33.5 years. The ages of the majority were between 20 and 45, only three of the patients being below the age of 20. Zabinski and Harkins had found that the greatest incidence was in the third decade, but this was not apparent in our series.

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There were eleven males and four females in this series, giving a ratio of approximately 3.6:1. Other authors have found the ratio varying from 3.5:1 to 9:1.

The trauma responsible for the splenic lesion was of a blunt nature in all cases but one. Five were the result of automobile accidents, and it is generally believed that the incidence of this lesion is gradually increasing with the rise in automobile accidents.[2, 4, 7] In all instances the site of injury could be localized to the left lower chest or left upper abdomen.

Six of the fifteen patients, or 40 per cent, had associated rib fractures. Special attention has been called to this coexisting injury by Waugh and Prior,[6] who collected eighteen cases with associated rib fractures in a series of seventy patients with delayed rupture of the spleen, an incidence of 23.4 per cent. The possibility of splenic rupture should always be kept in mind in any patient with fractures of the lower six ribs on the left.

TABLE I. DELAYED RUPTURE OF SPLEEN: TYPES AND SITES OF TRAUMA

NUMBER AND NAME	AGE (YR.)	SEX	TYPE OF TRAUMA	SITE OF TRAUMA
1. J. M.	58	M	Fell while inebriated	Left lower chest
2. E. I.	34	M	Beaten and kicked	Left chest, abdomen, and extremities
3. R. R.	41	M	Beaten	Head and upper body
4. W. S.	62	M	Automobile accident	Head, left chest, right arm
5. I. M.	34	F	Thoracentesis	Ninth intercostal space, postaxillary line
6. C. A.	30	M	Automobile accident	Contusions left leg and chest, face
7. S. V.	11	F	Fist blows by playmate	Left lower chest and abdomen
8. R. M.	25	M	Accident during automobile race	Left lower chest
9. D. M.	14	M	Blow with baseball bat	Left lower chest
10. R. B.	21	M	Automobile accident	Left upper abdomen and lower chest
11. L. F.	43	F	Automobile accident	Left lower chest posterior
12. M. N.*	10	M	Blow with baseball bat	Lower back on left
13. J. D.*	55	M	Struck by pipe which fell 50 feet	Left side of back
14. H. P.	45	M	Struck with pipe	Left flank
15. H. R.	20	F	Fist blow to abdomen	Left upper quadrant and left lower chest

*Latent period of 36 hours.

The latent period in our series ranged from a minimum of thirty-six hours to a maximum of fifteen days. The majority of secondary ruptures occurred between the second and fourth day. It was stated previously that McIndoe arbitrarily set a minimum of forty-eight hours necessary for delayed rupture, but we have included two patients with a latent period of thirty-six hours in this series. In both, however, there is no question as to the diagnosis of true delayed rupture. Following injury, each was completely asymptomatic until dramatic onset of secondary hemorrhage. It would seem that the length of the latent period is the result of the rapidity with which the subcapsular hematoma forms and ruptures.

The onset of secondary rupture was not associated with marked activity. In our series three patients were awakened from sleep with sudden pain, and six others were on restricted activity as hospital patients at the time of onset (Table II).

TABLE II. DELAYED RUPTURE OF SPLEEN: COEXISTENCE OF RIB FRACTURES AND LENGTH OF LATENT PERIOD

CASE	RIB FRACTURES	LENGTH OF LATENT PERIOD (DAYS)	ACTIVITY AT ONSET OF SECONDARY RUPTURE
1.	10, 11 left M.A.L.	2½	Ambulatory
2.	7 left P.A.L.	3	Sleeping
3.	8, 9, 10 left P.A.L.	4	Sleeping
4.	0	3½	Hospital bed patient
5.	0	4	Ambulatory
6.	0	10	Sleeping
7.	0	15	Hospital patient
8.	6, 7, 8 left A.A.L.	8	Hospital patient
9.	0	6	Ambulatory
10.	0	2	Hospital patient
11.	9, 10, 11 left paravertebral; 8, 9 right subscapular	2	Hospital patient
12.*	0	1½	Hospital patient
13.*	0	1½	Ambulatory
14.	11th left posterior	4	Ambulatory
15.	0	2	Ambulatory

M.A.L.—Middle axillary line.
P.A.L.—Posterior axillary line.
A.A.L.—Anterior axillary line.
*Latent period 36 hours.

DIAGNOSIS

The diagnosis can be made clinically without difficulty if the examiner is familiar with the signs and symptoms of delayed splenic rupture. The symptoms are primarily those of severe intraperitoneal hemorrhage, with the development of shock of a varying degree in a patient with previous injury to the left upper abdomen or lower chest. Pain referred to the left shoulder (Kehr's sign) was a persistent but not constant finding in our series, being present in twelve of the fifteen patients. Shifting dullness in the abdomen was another frequent sign, being elicited in ten instances. Upper abdominal pain and tenderness to palpation were not conspicuous findings. The presence of tenderness in the left upper quadrant was found in eleven patients, but the intensity was not marked. Diagnostic paracentesis was performed in only one of our patients, but some advocate its use routinely.[5] We do not feel that, in general, much is to be gained by this procedure, as exploration will be made if warranted, even in the event of a negative tap. Its chief value is in those patients in whom the diagnosis is obscure. Perhaps one of the best aids in diagnosis is a roentgenographic study of the abdomen, which may show medial or anterior displacement of the stomach with irregularity of the greater curvature, as well as downward displacement of the splenic flexure. The ingestion of a small amount of thin barium and examination of the stomach with the patient in the Trendelenburg position aid in establishing the presence of a perisplenic mass in the left subphrenic space.

TABLE III. DELAYED RUPTURE OF SPLEEN: SYMPTOMS AND SIGNS OF SPLENIC INJURY FOLLOWED BY INTRAPERITONEAL HEMORRHAGE

CASE	SYMPTOMS			SIGNS		
	ABDOMINAL PAIN	CHEST PAIN	SHOULDER PAIN	LEFT UPPER QUADRANT TENDERNESS	SHIFTING DULLNESS	FLUID WAVE
1.	+	0	+	+	+	0
2.	+	0	0	+	+	+
3.	+	0	+	+	+	0
4.	+	0	+	+	+	0
5.	+	0	+	+	0	0
6.	+	0	+	+	0	0
7.	+	0	+	+	0	0
8.	+	0	0	0	0	0
9.	+	+	+	0	+	+
10.	0	+	+	0	+	0
11.	0	0	+	0	+	0
12.*	+	0	+	+	+	0
13.*	+	0	+	+	+	0
14.	+	0	0	+	+	0
15.	+	0	+	+	0	0
Total	13	2	12	11	10	2

*Latent period 36 hours.

TABLE IV. DELAYED RUPTURE OF SPLEEN: PREOPERATIVE AND PATHOLOGIC DIAGNOSES

CASE	PREOPERATIVE DIAGNOSIS	PATHOLOGIC DIAGNOSIS	POSTOPERATIVE COMPLICATIONS
1.	Delayed rupture of spleen	Ruptured subcapsular hematoma	None
2.	Delayed rupture of spleen	Ruptured subcapsular hematoma	Partial wound separation with sinus tract formation
3.	Ruptured hollow viscus	Ruptured subcapsular hematoma	Mild atelectasis, left lower lobe
4.	Delayed rupture of spleen	Ruptured subcapsular hematoma	Pneumonia, left lower lobe
5.	Delayed rupture of spleen	Ruptured subcapsular hematoma	Subphrenic abscess
6.	Delayed rupture of spleen	Large amount of blood in capsule and multiple small hemorrhages	None
7.	Delayed rupture of spleen	Traumatic hemorrhage, subcapsular hematoma	None
8.	Delayed rupture of spleen	Subcapsular hematoma; multiple lacerations	None
9.	Delayed rupture of spleen	Subcapsular hematoma, laceration superior pole	None
10.	Delayed rupture of spleen	Four surface tears; subcapsular hematoma	None
11.	Delayed rupture of spleen	Laceration upper pole	Pulmonary infarction, hemothorax, pleural effusion
12.*	Delayed rupture of spleen	Deep laceration with hematoma	None
13.*	Delayed rupture of spleen	Subcapsular hematoma with splitting of capsule	None
14.	Delayed rupture of spleen	Multiple lacerations	Left pleural effusion
15.	Delayed rupture of spleen	Ruptured subcapsular hematoma	None

*Latent period 36 hours.

The more common causes of diagnostic errors, described by Bailey and Schreiber,[1] include absent visible signs of injury to the anterior abdominal wall, a misleading history, a state of shock thought to be caused by the associated

injuries, and a false sense of security initiated by the recession of the primary symptoms. In our series the correct diagnosis was made preoperatively in all but one of the cases.

TREATMENT

Once the diagnosis has been established, the treatment is emergency splenectomy. The mortality of unoperated cases is reported as 90 to 100 per cent. Attempts at any procedure short of splenectomy are not indicated since they subject the patient to an unnecessarily greater risk. The mortality has varied considerably in different series, Zabinski and Harkins[5] reporting 10 per cent, and McIndoe[2] 27 per cent. In our series of fifteen cases the mortality was 0.0 per cent.

The postoperative complications, which occurred in five patients, consisted of partial wound separation, left lower lobe atelectasis, left lower lobe pneumonia, subphrenic abscess, pleural effusion, and pulmonary infarct, in one case each.

PATHOLOGY

All spleens removed showed no evidence of pre-existing disease. Eleven of the fifteen spleens showed definite subcapsular hematoma, which was massive in some instances and multiple in others (Table IV).

CASE REPORTS

We are presenting three cases in detail. The first is a classical example of delayed rupture; the second demonstrates the prevention of rupture by close observation and surgical intervention; and the third is an unusual one, which demonstrates one of the inherent dangers of thoracentesis.

CASE 1.—R. R., a 41-year-old white man, was admitted to Cincinnati General Hospital on May 16, 1952, in profound shock. History revealed that three days prior, while on a drinking bout, he was involved in a fight and was beaten rather severely. He resumed work as a musician the following day. He was asymptomatic except for some residual stiffness from the beating. On the morning of May 16, he awakened from sleep with severe abdominal pain and a feeling of weakness. During the day he became progressively weaker, and presented himself at the Receiving Ward in the early afternoon in shock.

Upon admission, blood pressure was 80/60, pulse 140, respiration 30. Physical examination revealed a right periorbital ecchymosis and a suboccipital hematoma. There was marked limitation of respiration, with pain and splinting of the left side of the chest. Abdomen was distended and tympanitic. There were no masses palpable, no shifting dullness. Tenderness was elicited in the left upper quadrant and rebound tenderness was referred to this region. Hemoglobin upon admission was 12.0 Gm., white blood count 15,600, and urinalysis negative. Chest roentgenogram revealed fractures of ribs 8, 9, and 10 posteriorly on the left side. Immediately prior to operation the hemoglobin had dropped to 10.0 Gm.

An exploratory laparotomy was performed under general anesthesia after a preoperative diagnosis of delayed rupture of the spleen had been made. Two thousand cubic centimeters of free blood was found in the peritoneal cavity. Splenectomy was performed, and the spleen showed a large subcapsular hematoma with a large rent in capsule overlying the hematoma. Postoperatively, the patient had a smooth course except for mild atelectasis, and he was discharged from the hospital on the seventeenth postoperative day.

CASE 2.—M. K., a 56-year-old white woman, was in an automobile accident on Oct. 4, 1953. Upon arrival at the Receiving Ward, she was bleeding from the left external auditory canal and was admitted to the Neurosurgical Service of the Cincinnati General Hospital for observation for possible fracture of the skull.

Upon admission her blood pressure was 120/80, hemoglobin 12 Gm., white blood count 9,000, and urinalysis negative. Physical examination was negative except for the bleeding noted. Skull roentgenograms were negative for fracture. Chest film showed a transverse fracture of left fifth rib in the posterior axillary line, with a slight left pleural effusion.

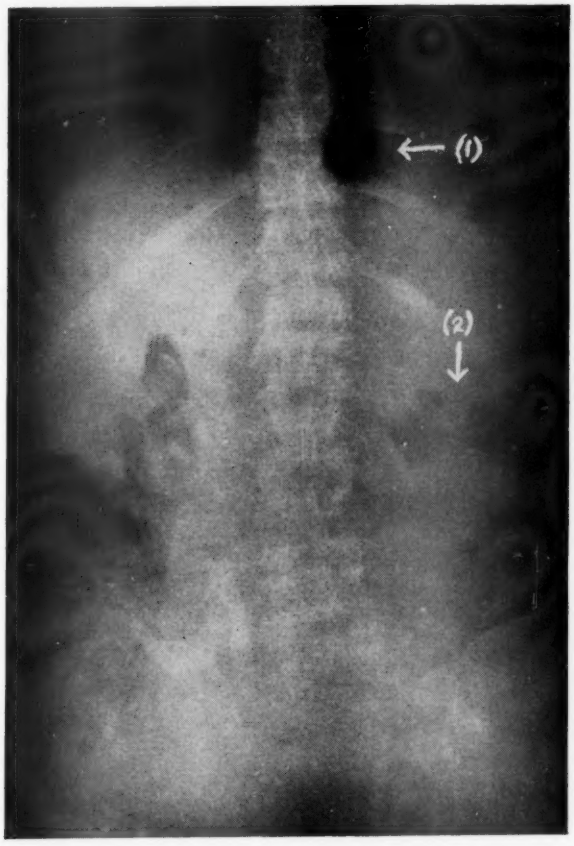


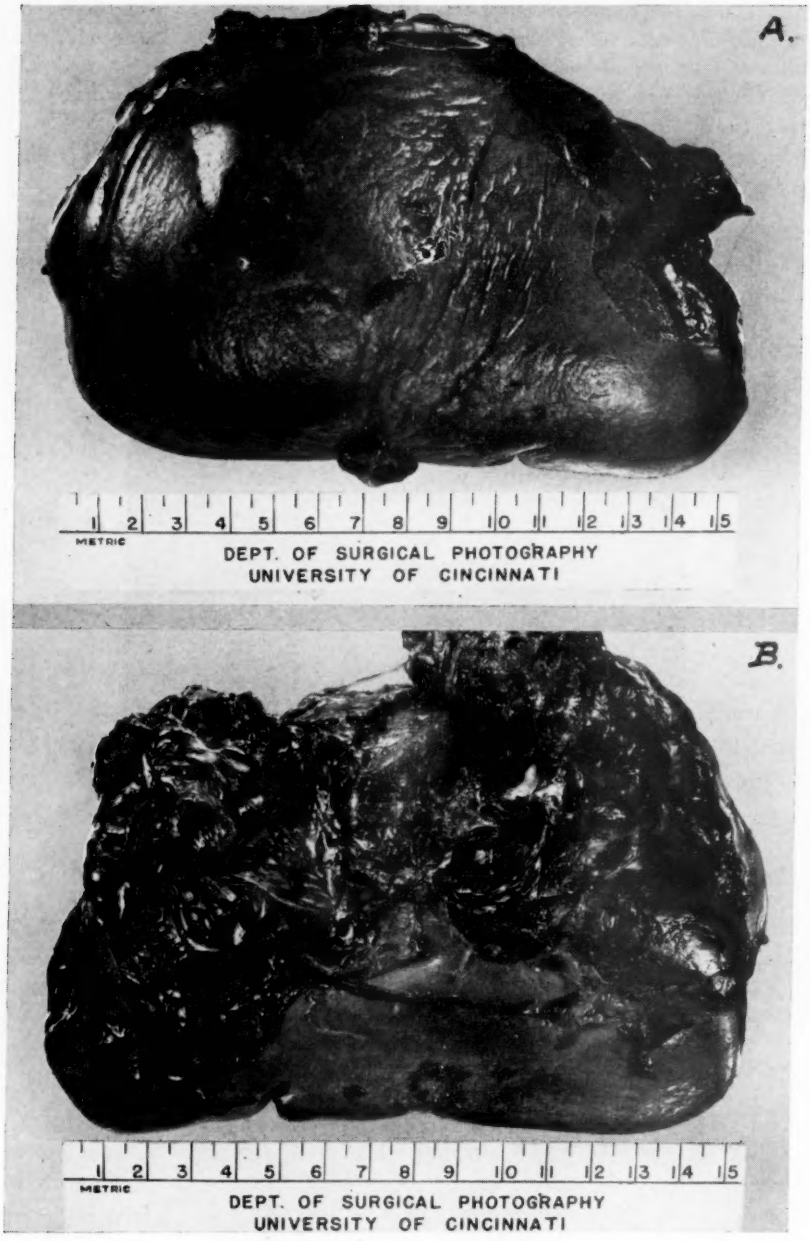
Fig. 1.—Roentgenogram of abdomen showing medial displacement of gastric bubble (1) and downward displacement of the splenic flexure (2) by mass developing from a ruptured spleen.

On October 14, thoracentesis through the eighth intercostal space in the posterior axillary line yielded 220 c.c. of old blood. The patient complained of left shoulder pain during this procedure. On October 16, a repeat thoracentesis yielded 200 c.c. of serosanguineous fluid. On October 19, two additional aspirations were attempted without success, although there was persistent x-ray evidence of fluid. On October 22, three thoracenteses were attempted without success. Chest films still showed fluid on the left side. On October 23, an upper gastrointestinal series was made and this was interpreted as showing anterior and medial displacement of the stomach and downward displacement of the splenic flexure.

The patient was seen in consultation the same day by Surgical Staff. Hemoglobin had dropped to 10.0 Gm., white blood count had risen to 16,000. Examination at this time revealed dullness in the left lower chest and left upper quadrant. There was no shifting dullness, and no masses could be felt. Cullen's sign was positive.

In view of these laboratory and clinical findings, the patient was explored. A small amount of old blood was found in the peritoneal cavity, and the omentum was noted to be

A.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B.

Fig. 2.—*A*, Photograph of spleen, removed at operation from patient in Case 3, showing rupture of capsule.

B, Same specimen which has been sectioned to reveal the subcapsular hematoma.

adherent to the spleen. After separation of the omentum and evacuation of the old clots, the spleen began to bleed actively. It was noted that the spleen was severely fractured, and splenectomy was therefore performed. The patient's postoperative course was smooth, and she was discharged on the fifteenth postoperative day.

CASE 3.—I. M., a 34-year-old Negro woman, was admitted to the Medical Service of Cincinnati General Hospital on July 19, 1952. Previously she had been admitted in April, 1950, with the diagnosis of alcoholism and cirrhosis. She had abstained from alcohol thereafter, and disappearance of hepatomegaly and return of normal liver function occurred. She was seen in the Obstetrical Clinic in the seventh month of pregnancy. A chest film taken during this clinic visit showed a suspicious lesion in the left upper lobe and a left pleural effusion. She was admitted for further study.

Physical examination upon admission revealed signs of fluid at the left base and râles in the left upper lobe. The liver was felt to be 1 cm. below the right costal margin, edge was sharp. Hemoglobin upon admission was 13.0 Gm., white blood count 8,500, and urinalysis negative.

On July 22, two attempts at thoracentesis through the left posterior axillary line produced only 10 c.c. of blood. The patient complained immediately of left shoulder pain. Roentgenographic studies made later the same day revealed left pleural effusion and an active acid-fast infection of the left upper lung field. Films of the abdomen showed a seven-month pregnancy and a soft tissue mass in the left upper quadrant displacing the air bubble of stomach medially and the splenic flexure of the colon downward. (Fig. 1).

The patient continued to complain of epigastric and left shoulder pain for the next few days. On the morning of July 25, the pain seemed much less. At 6:00 P.M. the same day, she suddenly developed severe epigastric pain radiating into the left lower quadrant, and her pulse rose to 124. Blood pressure was 130/80, hemoglobin 8.5 Gm., white blood count 15,200. Skin was cold and clammy. The upper abdomen appeared to be full and there was bulging of an umbilical hernia. Surgical consultation was obtained. She was explored immediately after a diagnosis of delayed rupture of the spleen was made. Three thousand cubic centimeters of blood was found in the peritoneal cavity, and the spleen was completely lacerated. During splenectomy the patient's blood pressure fell precipitously but was re-established with the infusion of 3 units of blood. On the third postoperative day she delivered a stillborn, 36-week-old fetus. The patient then developed a subphrenic abscess which required incision and drainage on August 22. She was discharged on September 24. The pathologic report indicated a rupture of subcapsular hematoma of the spleen (Fig. 2). A definite hemorrhagic tract could be seen extending from hilum to the convex border of the spleen, and this was thought to be the result of the passage of the thoracentesis needle.

SUMMARY AND CONCLUSIONS

The clinical picture presented by patients with delayed rupture of the spleen is sufficiently definite to permit an accurate diagnosis and prompt institution of treatment with emergency splenectomy.

This diagnosis should be thought of in any individual suffering recent trauma to the left lower chest, upper abdomen, or back, especially in the presence of rib fractures. The most valuable clinical findings which aid in establishing the diagnosis are left shoulder pain, left upper quadrant tenderness, shifting dullness in the abdomen, and shock of a varying degree. The finding of shifting dullness is a simple and important diagnostic test which should be employed much more often.

The correct diagnosis was made in fourteen of the fifteen patients, and in only one case was a diagnostic paracentesis performed. However, there was adequate indication in this case for emergency exploration without abdominal

paracentesis. The use of abdominal roentgenograms is advocated as a diagnostic aid, and abdominal paracentesis is recommended only in those cases in which the diagnosis is indefinite or obscure. With accurate preoperative diagnosis and prompt therapy, it has been possible to reduce the mortality rate to 0 per cent in our series of fifteen cases.

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Surgical Technique

EXTENDED OPERATION FOR CARCINOMA OF THE BREAST

SURGICAL TECHNIQUE

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IN THE treatment of cancer of the breast, physicians have tried cautery, simple and radical operative procedures, irradiation, biochemicals, and combinations of these with varying degrees of success. The surgeon has contributed to the cure rate by ever increasing the magnitude of the operation. In 1867, Charles Moore[9] advised the excision of the entire breast in patients with breast cancer. Samuel W. Gross[4] in 1880 recommended dissection of the axilla when the axillary lymph nodes were involved with metastatic cancer. Lothar Heidenhain[7] in 1889 removed the superficial part of the pectoralis major muscle and the entire pectoralis major muscle when the carcinoma was adherent to the chest wall. William S. Halsted[5] in 1894 standardized the operation of radical mastectomy for carcinoma of the breast. In the same year (1894) Willy Meyer[8] reported a similar operation.

In 1889, Dr. Halsted wrote, "Dr. W. H. Cushing, my house surgeon, has in three instances cleared out the anterior mediastinum on one side for recurrent cancer. It is likely, I think, that we shall in the near future remove the mediastinal contents at some of our primary operations."[6] Gordon-Taylor[3] (1948) removed the anterior mediastinal lymph glands with the internal mammary vessels after resection of the second and third costal cartilages in carcinoma of the breast. Wangensteen[11, 12] (1950) extended the radical operation to include a radical neck, supraclavicular, and mediastinum dissection. Ehrenhaft[1] (1951) reported pneumonectomy with extensive hilar lymph node resection for metastatic breast carcinoma in the lung. Gardner[2] (1951), at Duke University, has combined supraclavicular and internal mammary chain dissection with radical mastectomy. Urban[10] (1952) has resected the chest wall from the first to the fifth intercostal spaces including the costal cartilages, a 1 cm. wide segment of the sternum, the internal mammary lymph nodes and blood vessels, and the underlying pleura. This segment of chest wall is removed in continuity with the overlying pectoralis muscles.

In a small series of patients with carcinoma of the breast, we have combined the neck and supraclavicular dissections as advocated by Wangensteen with that of Urban of resection of the chest wall overlying the internal mammary lymph chain. In addition, we have removed the clavicle as a primary procedure to facilitate the dissection.

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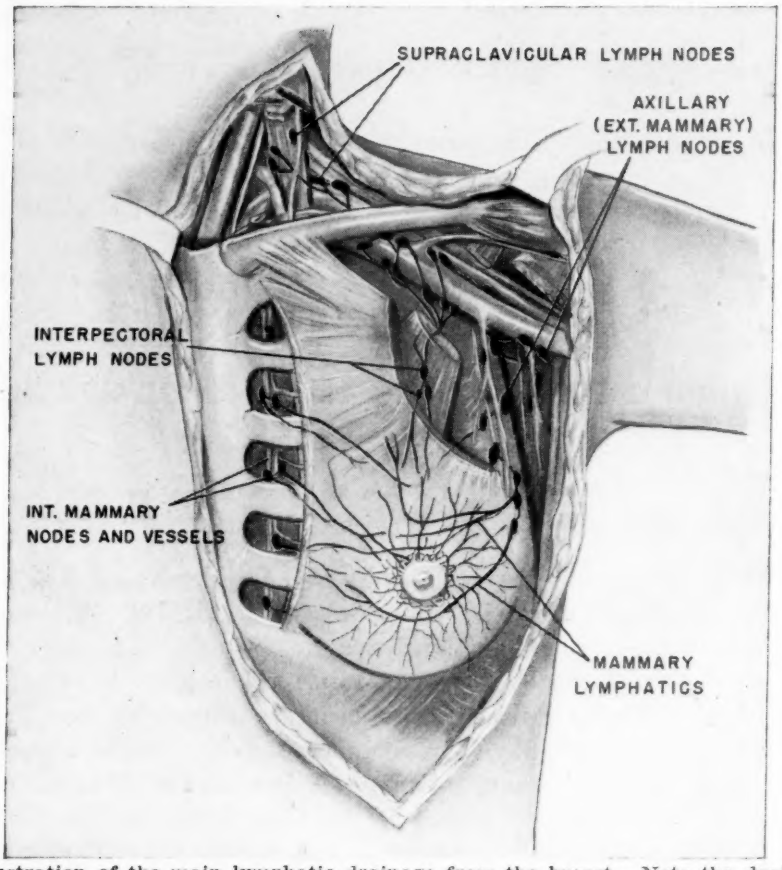

Fig. 1.—Illustration of the main lymphatic drainage from the breast. Note the drainage from the medial half of the breast to the internal mammary lymph chain.

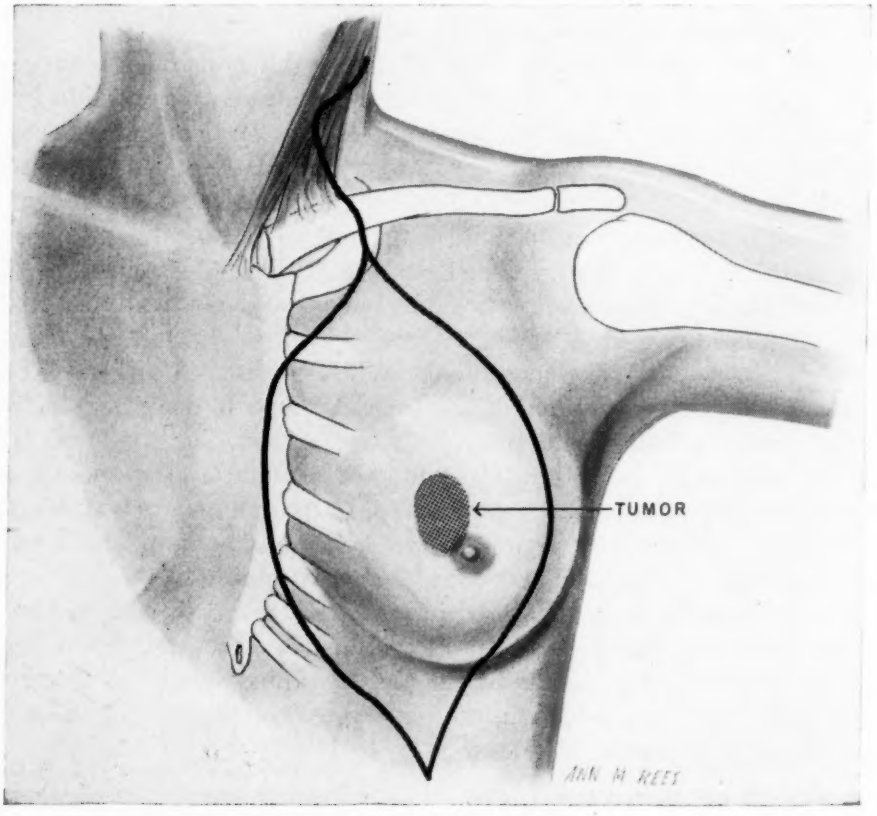

Fig. 2.—This illustrates the line of incision which begins in the neck and crosses the clavicle 4 cm. from its medial end and is continued downward and well around the nipple and tumor.

OPERATIVE TECHNIQUE

Under intratracheal anesthesia, the neck, shoulder, arm, chest, abdomen, and one thigh are well prepared with antiseptic agents. The incision begins on the neck midway between the clavicle and the mastoid process. It is carried downward and medially in a collarlike fashion, then downward and

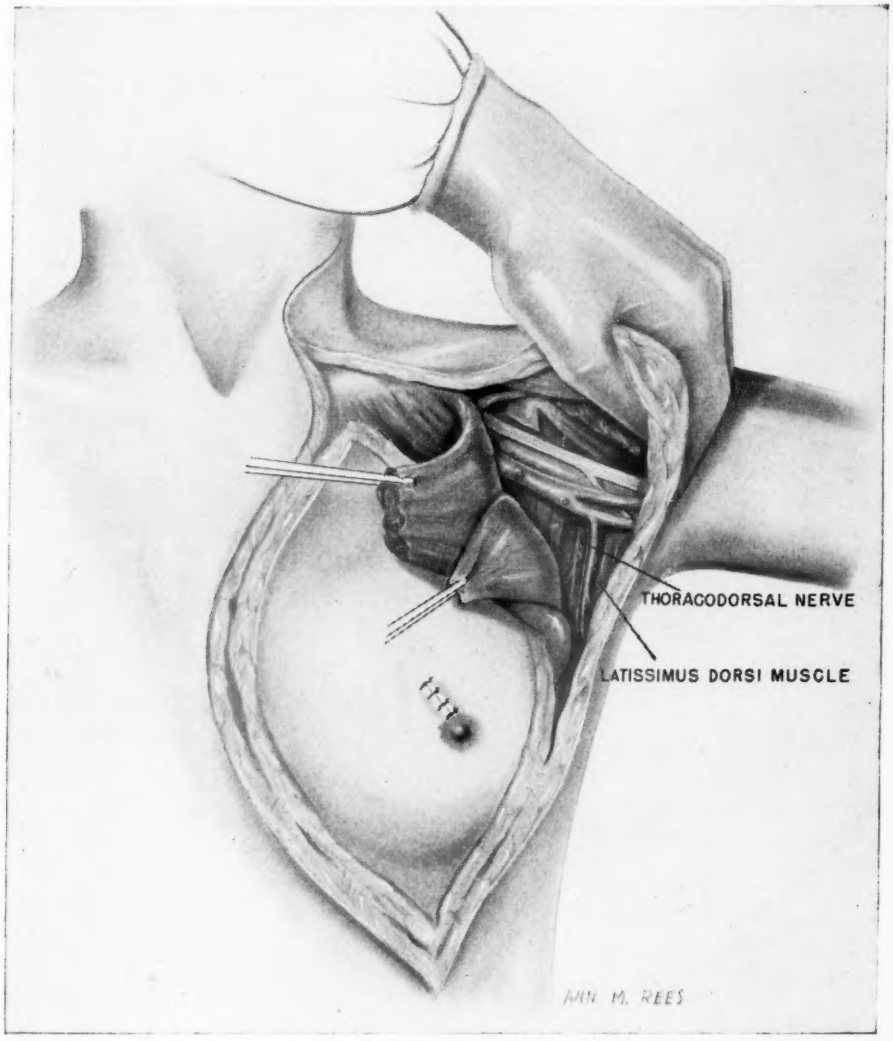

Fig. 3.—The operation begins by a careful dissecton of the axilla. The long thoracic and thoracodorsal nerves are preserved unless involved with cancer.

across the medial end of the clavicle 4 cm. from the sternoclavicular junction. It is continued about the breast allowing a wide margin around the nipple and the tumor (Fig. 2).

The dissection begins by mobilizing the skin flaps of the breast. The pectoralis major and minor muscles are transected at their insertions on the humerus and coracoid process, respectively. This allows a clean dissection of the neurovascular bundle below the clavicle (Fig. 3).

At this point, the skin flaps of the neck and shoulder are developed, and the ribbon muscles over the thyroid gland are mobilized and divided at their insertions on the thyroid bone. The sternocleidomastoid muscle is transected at the junction of its upper middle thirds. Care is exercised not to injure the spinal accessory nerve. The internal jugular vein is divided and ligated at the same level. Later in the dissection, it is again ligated and divided at its

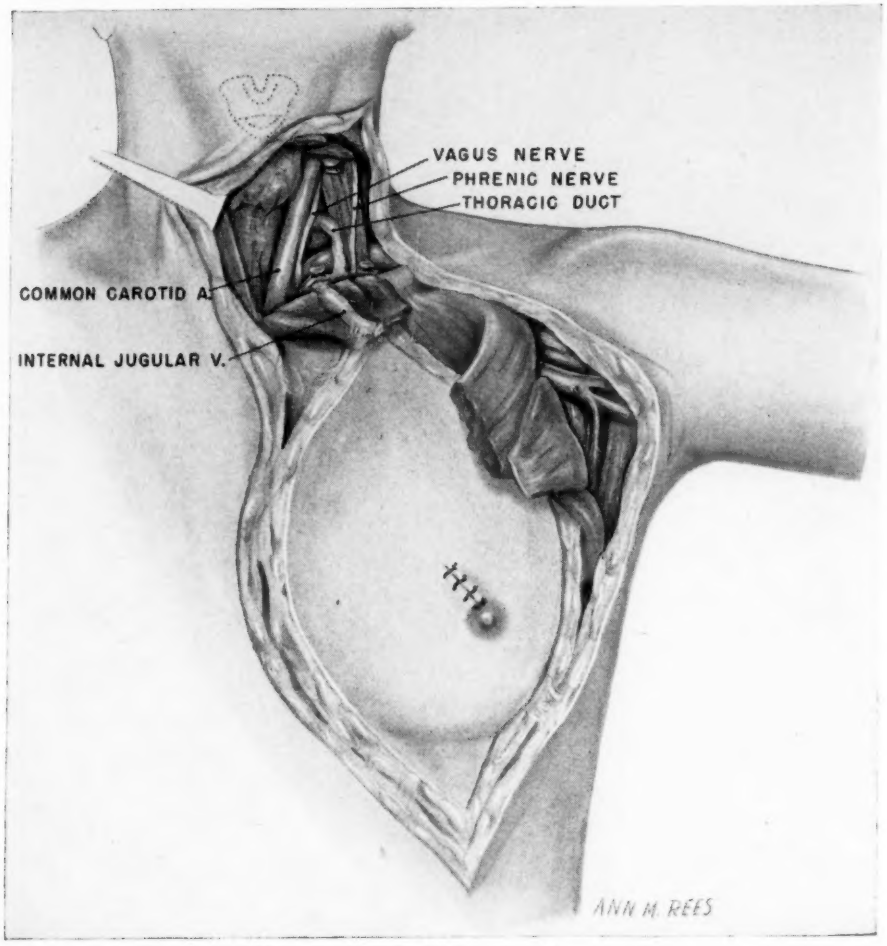

Fig. 4.—This illustrates the neck dissection. All structures are carefully cleansed. The internal jugular vein is removed and the thoracic duct is ligated if injured.

confluence with the subclavian vein. The carotid artery and vagus nerve are carefully cleansed of all surrounding tissue. The thoracic duct, which often rises high above the clavicle on the left side, is located and preserved. If it is injured it must be ligated. The neck dissection continues downward to expose the brachial plexus. The omohyoid muscle is transected near the scapular. It is difficult to dissect out important nerve structures in the supraclavicular fibrofatty tissue, and injury to the spinal accessory nerve or to the

suprascapular or subscapular components of the brachial plexus is a constant danger (Fig. 4). As the operation progresses the supraclavicular and infraclavicular dissections approach one another.

The clavicle is then transected with a Gigli saw just proximal to the choricoclavicular ligaments. The subclavian muscle is likewise divided, and the clavicle is disarticulated at its medial end. The subclavian and innominate

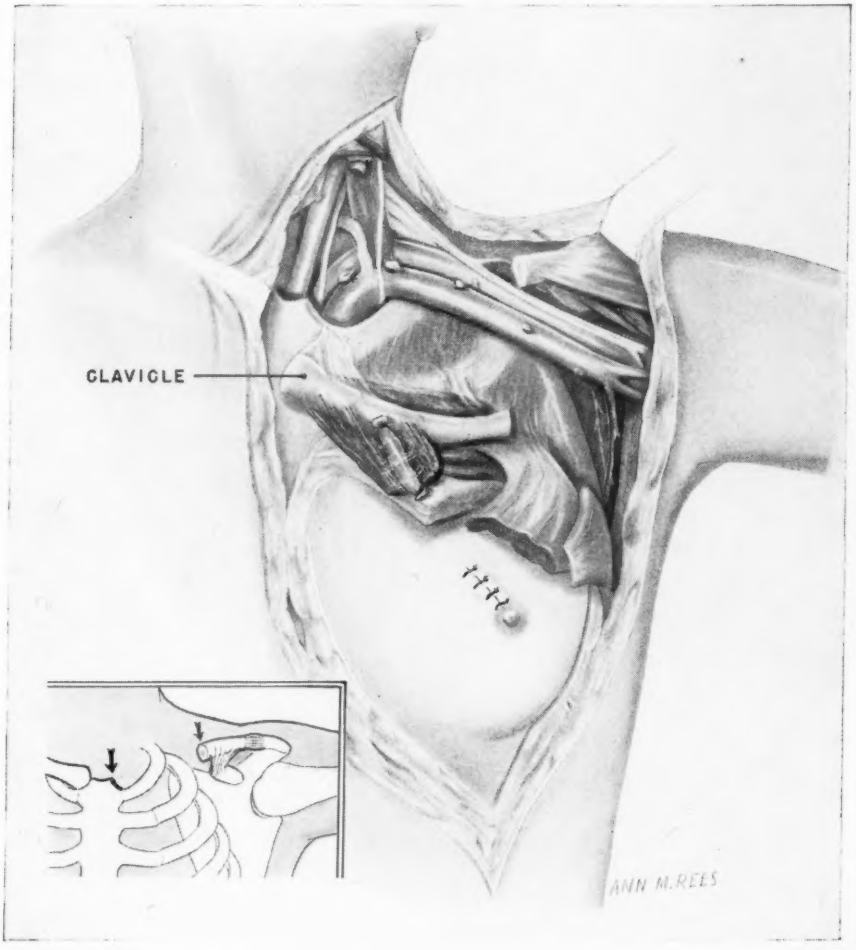

Fig. 5.—The clavicle is transected just proximal to the choricoclavicular ligament and disarticulated at its medial end. Note the transverse scapular nerve which could be easily injured.

veins lie close to the posterior surface of the head of the clavicle and can be easily injured at this point. The shoulder falls backward after division of the clavicle, and the dissection in this region is easily completed (Fig. 5).

The internal mammary blood vessels are found and ligated just below the lower border of the first rib. They are again ligated in the fifth intercostal space. A sternal knife is inserted through the pleura in the first intercostal space and tapped downward, removing a 1 cm. wide margin of sternum. If the knife is tilted toward the midline, the sternal edge is beveled. This

maneuver modifies the precipitous medial margin of the chest defect and results in less dead space between skin flaps and fascia graft. The ribs are divided about 5 cm. from the sternum and this fragment of the chest wall is reflected laterally in continuity with the overlying pectoral muscles and breast (Fig. 6). The tissues of the neck and supraclavicular space, the clavicle, axillary contents, breast, and chest wall are removed in one piece.

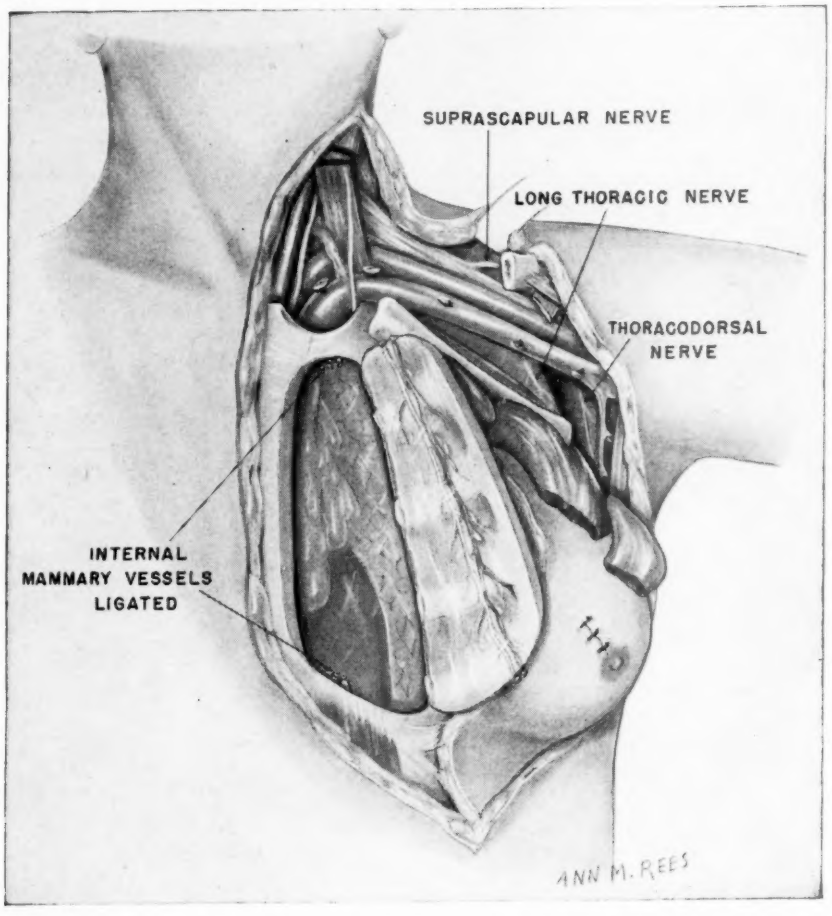

Fig. 6.—This illustrates the technique of resection of the chest wall between the first and sixth ribs. This should be carried out in continuity with the overlying pectoral muscles.

A fascia lata graft approximately 11 by 19 cm. is removed from the thigh through a lateral longitudinal incision. All fat is removed from the fascia before repair of the chest defect. The graft is implanted using the method described by Urban. No. 1 chromic catgut mattress sutures are passed through the graft and around each rib, where they are tied snugly. Large, curved cutting needles are used to pass the sutures through the margin of the sternum. If the cut edge of the sternum has been beveled, the needles pass readily through the posterior cortex. The graft so placed is in continuity with the deep surface of the chest cage and should be under moderate tension to prevent paradoxical motion during respiration. The free edges of

the graft are draped over the bone margins and sutured in place with No. 0000 silk (Fig. 7). A No. 24 Fr. catheter is placed in the chest with the tip under the graft and connected to a water trap.

The wound is thoroughly irrigated with normal saline solution and closed. Urban has used stay sutures to reduce tension on the suture line (Fig. 8). If the skin flaps cannot be approximated, a skin graft 0.017 inch in thickness can be applied directly to the fascia lata graft or it can be applied

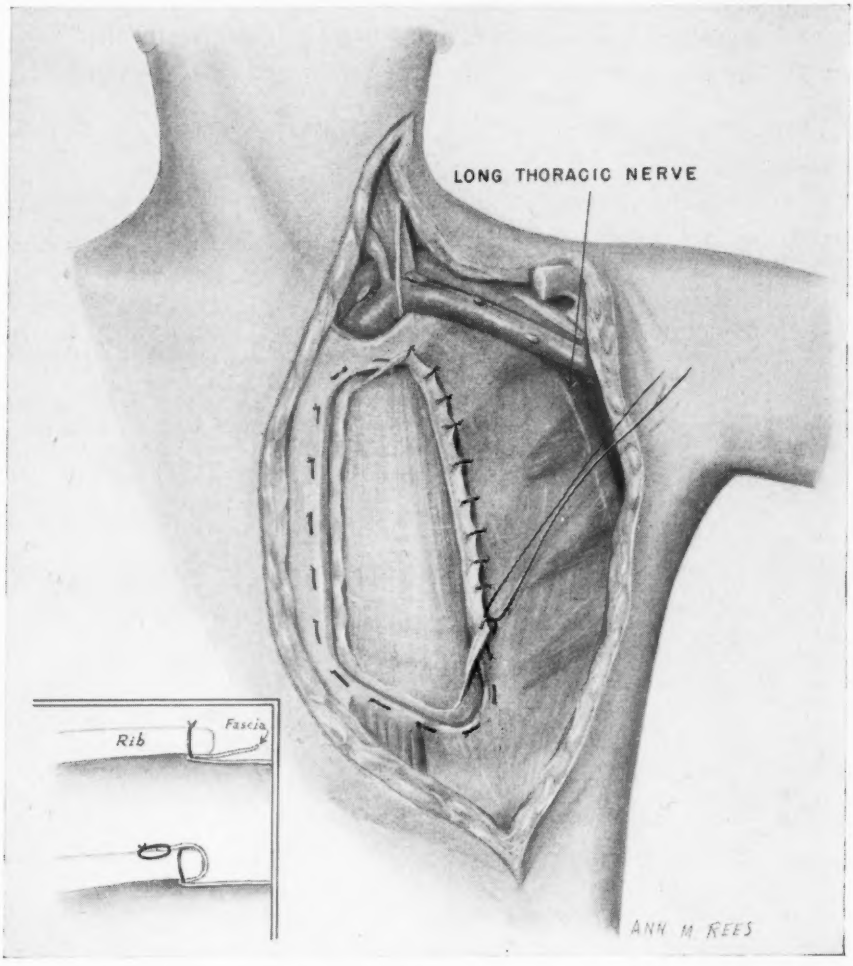

Fig. 7.—The chest wall is repaired by Urban's technique using a fascia lata graft.

later after the development of granulation tissue. Mechanics waste, held in place with 8-inch stockinette cut on the bias, is used as a light pressure bandage. If necrosis of the skin develops, the opposite breast can be mobilized and shifted so that the wound can be closed.

COMMENT

Operative success depends on good anesthesia, blood, antibiotics, and good nursing care. The arm is kept at a ninety-degree angle to the body and fifteen

degrees forward of a plane through the shoulders. The chest drain is removed in two to three days and the neck and axillary drains in four to five days. The patient is instructed in, and practices, lung and leg exercises prior to surgery and is encouraged in them after surgery. Downward and forward rotation of the shoulder is prevented by designed exercises to strengthen the trapezius and rhomboidi muscles. They are started two to three weeks after surgery. If the shoulder is held upward and backward, there is less angulation of the subclavian vein over the upper margin of the first rib and therefore less postoperative edema of the arm. When the clavicle is removed, the shoulder is shortened about 3 cm. The pyramidal axillary

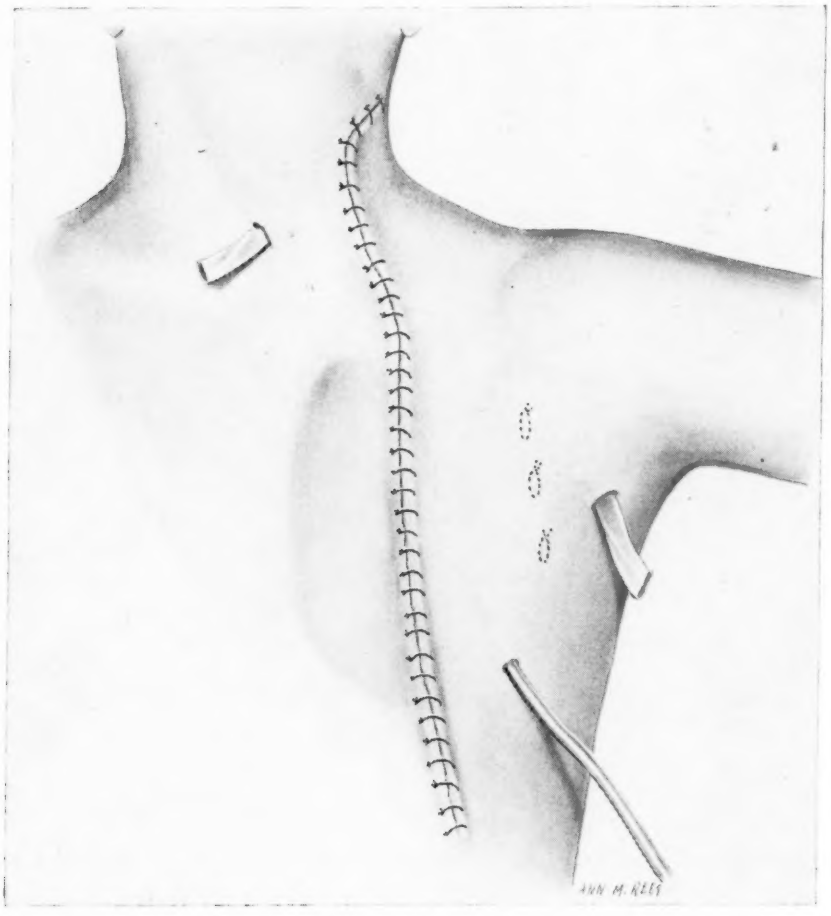

Fig. 8.—The wound is closed with drainage of the chest, axilla, and neck.

space is reduced in volume, and there is less postoperative scarring and therefore less obstruction to the return flow of blood. The factor of venous obstruction seems to me to play equally as important a part as lymphatic obstruction in postoperative edema of the arm following radical surgery for breast carcinoma.

This extended operation has been performed on six patients with carcinoma of the breast. In five patients the functional result is excellent with minimal edema of the arm (1 cm. or less in circumferential measurements). In one obese patient who refused to follow exercise instructions, the functional result is less impressive, and the circumferential measurement of the arm of the operated side is 3 cm. greater than that of the nonoperated side.

SUMMARY

The technique of an extended operation for carcinoma of the breast with primary removal of the clavicle is presented.

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Surgical History

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SURGERY FOR MITRAL STENOSIS

SOME ASPECTS OF ITS EVOLUTION

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NOW that commissurotomy for mitral stenosis has become a well-established procedure throughout the world, the youngest generation of physicians is likely to think of it as an old operation. Because the road to this end has been a long and tortuous one, it seems important to review the steps that led to it. Why was it that an operation which was performed successfully in 1925 by a well-known English surgeon should not have been tried again until 1946? And during this long period, much work was done on the subject, and surgeons familiar with Souttar's report[47] in 1925 did not consider it worth while. The full answer to this question cannot be given, but the various attacks, during the years, on this problem can be reviewed.

As far back as 1872, valvular defects in dogs were created experimentally by men interested in the physiologic changes thus produced. Becker,[7] a German ophthalmologist, created aortic regurgitation in dogs by passing glass rods down the carotid artery and injuring the aortic cusps. He was interested in studying the pulsations of the retinal arteries in such a condition. After him, Klebs[31] in 1876, Cohnheim[15] in 1877, Rosenbach[41] and Timofejew[49] in 1888, and others also produced valvular defects by passing instruments down through the carotids and jugulars. None of them was interested in the surgical implications of such work.

In 1898, Samways,[42] a cardiologist in England, following a discussion about peristalsis in the auricle of the heart, concluded with these words, "I anticipate that with the progress of cardiac surgery, some of the severest cases of mitral stenosis will be relieved by slightly notching the mitral orifice and trusting to the auricle to continue its defense." In 1902, following the article by Sir Lauder Brunton[13] on February 7 in *Lancet,* about which more will be said later, he repeated the words quoted previously and then went on to say,

> Believing, as I there maintained, that the auricle in cases of mitral stenosis has an important role in preventing regurgitation at the mitral, it seems to me probable that slightly notching the valve, though increasing the incompetence at the orifice, would not result in a regurgitation comparable in evil to the advantages gained by facilitating the onflow. It is, however, very important that the orifice should not be cut too freely. Sufficient stenosis should remain to render a prolonged contraction of the auricle necessary to fill adequately the ventricle so that the auricular contraction may continue into the ventricular-systolic time and help to prevent regurgitation at the mitral orifice.

On Feb. 8, 1902, Sir Lauder Brunton[13] published a short article in *Lancet,* in which he expressed his belief that the harmful effects of mitral stenosis could be counteracted by operating on the valve. What he had to say seems well worth repeating here.

> Mitral stenosis is not only one of the most distressing forms of cardiac disease but in its severe form, it resists all treatment by medicine. On looking at the contracted mitral orifice in a severe case of this disease, one is impressed by the hopelessness of ever finding a remedy which will enable the auricle to drive the blood in sufficient stream through the small mitral orifice and the wish unconsciously arises that one could divide the constriction as easily during life as one can after death. The risk which such an operation would entail naturally makes one shrink from it but, in some cases, it might be worth while for the patients to balance the risk of a shortened life against the certainty of a prolonged period of existence which could hardly be called life, as the only conditions under which it could be continued might to them be worse than death. . . . But no one would be justified in attempting such a dangerous operation as dividing a mitral stenosis on a fellow creature without having first tested its practicability and perfected its technique by previous trials on animals. Accordingly, I obtained a license and certificates a year ago in order to make the necessary experiments, but unfortunately other calls upon my time have not allowed me to do more than make trial experiments of dividing stenosed valves in diseased hearts from the post-mortem theatre and on healthy valves in the hearts of cats, and also to try the proposed operation in the dead animal. It may be some months longer before I can get anything more done and I therefore think that it may be worth while to write this preliminary note, especially as after all, if the operation is to be done in man, it will be surgeons who will do it and they must, of course, make their own preliminary experiments, however fully the operation may be described by others, and each must find out for himself the method which he will enploy in each particular case.

One week after this article appeared in *Lancet,* a leading article was published in that journal[32] taking Sir Lauder to task for proposing that others carry out a highly dangerous operation which he himself had not fully perfected. It discussed the grave nature of the operation and then stated that there was no evidence that a valve that had been divided would not promptly heal in its old form, or in a worse condition. Furthermore, it was pointed out that the mitral insufficiency created by the operation might prove as serious as the original condition. At this time, Sir Lauder was one of the leading cardiologists in England, an internist, not a surgeon. There was never any question of his attempting to perform the operation on a patient. He believed the operation a sound one and that it should be perfected by surgeons. The week after *Lancet's* leading article attacking Sir Lauder, a letter from Sir Arbuthnot Lane[33] appeared. He said that his colleague, Dr. Lauriston Shaw, had some years before suggested to him the possibility of operating on a patient with mitral stenosis and that they had been waiting for a suitable case in which to perform the operation. He felt that the operation was feasible and "under certain circumstances, justifiable." The next week there was a letter in *Lancet* from Lauriston Shaw.[45] He commended the editors for their attack on Sir Lauder and corroborated the statement made by Sir Arbuthnot that he

had thought of the surgical attack on mitral stenosis at least twelve years earlier. However, he wished it understood that he did not consider operation justifiable. He wrote,

> I shall be obliged if you will allow me to state that the a priori arguments against the probability of any patient deriving benefit from the operation seemed to me so conclusive that I deliberately decided against regarding it as a justifiable therapeutic measure. These arguments are so clearly summarized in your leading article of February 15 (p. 451) that your readers will, I think, agree with me that Sir Lauder Brunton's chief task is not to show his surgical colleagues that it is possible to enlarge the stenosed mitral orifice, but to persuade his medical colleagues that such a proceeding is useful. It is possible to do many things that are useless and some things that are harmful.

It is interesting that this exchange was between a man who was later to be Physician to Guy's Hospital and the man who was then the Consulting Physician to St. Bartholomew's. Sir Lauder was not only one of the most distinguished physicians in England but was a Fellow of the Royal Society. Thus, two leading cardiologists fought over the wisdom of surgical treatment for mitral stenosis.

After this interchange of articles and letters in 1902, I have been unable to find any further discussion of the subject by any of the authors. Sir Lauder continued to contribute many articles to medical literature. Recently an explanation for his silence was given to me by Dr. Penrhyn Jones[30] of England. He drew my attention to a statement made by Sir Lauder in an article in the *Northumberland and Durham Medical Journal* in 1909 in which he said "that he had intended to continue his work on the investigation as to the possibility of the surgical treatment of mitral stenosis but he had developed blood poisoning soon after the initial experiments and had to give up the work." He, therefore, published no other paper dealing with this subject. In searching the literature for further articles by Samways on this subject, I have found that he contributed articles on the heart every year, except during World War I, and up through 1921, but none referred to his original suggestion.

During the succeeding years, much experimental work was done abroad and in this country. All were agreed that mitral stenosis could be treated by resection of a segment of a mitral valve cusp but that some degree of insufficiency would follow. It was thought, however, that the insufficiency could be better tolerated than the stenosis. In this country, work was done at The Johns Hopkins Hospital by MacCallum,[36] Cushing,[16] Branch,[11] and Bernheim[8] from 1907 to 1909. Unsuccessful attempts were made to create mitral stenosis in the experimental animal. MacCallum[36] did devise an instrument called the cardiotome with which segments of the mitral valve leaflets could be resected in the dog. If the segments were not too large, the dog recovered. Thus, they were able to show that the normal dog could tolerate experimentally produced mitral regurgitation. Rudolph Haecker[24] in Germany also carried out experiments on dogs but he operated on the open heart, after occlusion of the venae cavae and great vessels, and only one of the thirteen dogs survived. In 1912, Schepelmann[43] incised the mitral valves of dogs by means of long-

handled tenotomes passed through the ventricular wall. Jeger[29] in 1913 published a monograph on heart surgery and devoted thirty-three pages to the history of this subject. He proposed that vascular shunts be used in the treatment of stenosis of the aortic and mitral valves. For aortic stenosis, he made a successful anastomosis between the left ventricle and the innominate artery in the dog by means of a vein graft. The dog lived for four days and then died as a result of thrombosis in the graft and in the ventricle. The anastomosis was intact. For mitral stenosis, he proposed a shunt between the left ventricle and a pulmonary vein, also using a vein graft. This was not attempted but the idea of getting more blood into the ventricle was in accord with ideas expressed many years before by Samways.[42]

In 1913, Doyen[20] published a short report in *La Presse médicale* describing his operation on a woman of twenty. He had made the diagnosis of infundibular stenosis of the pulmonary artery and, at the operation, passed a tenotome in through the right ventricular wall and cut the valve. Unfortunately this did not improve the blood flow through the valve sufficiently, and she died several hours later. At autopsy, his diagnosis of infundibular stenosis was confirmed, but she also had a ventricular septal defect, and the two lungs were so underdeveloped that they did not exceed the heart in size. After reporting this case, he went on to say that he felt the same operation could be performed for mitral stenosis and that he had worked out the details for such a procedure and expected to perform the operation. Unfortunately, France became involved in World War I in 1914, and Doyen died in 1916, without publishing anything further on heart surgery.

In 1914, Carrell[14] and Tuffier[50] published the results of their many experiments in heart surgery. They carried out many types of operations on the valves, using the open heart technique after occlusion of the venae cavae. Although they were able to perform many procedures successfully, the cerebral anoxia produced by the caval obstruction caused permanent brain damage in all cases. In one experiment with a closed circulation, they were able to produce pulmonary regurgitation by an ingenious operation on the base of the valve. All of their work demonstrated how much surgery the heart would tolerate.

Allen and Graham[1] in 1922 devised a cardioscope with which they could visualize the mitral valve and also cut the leaflets. At first, they used the ventricular approach, but so many dogs died that they shifted to an approach through the auricular appendage. Following this change in technique, they were able to operate on a large number of dogs without mortality. They were in search of a suitable patient on whom to operate, but none of their medical colleagues were convinced of the value of the operation and would not refer a patient. Finally,[23] a country doctor referred a patient to them who was very sick as the result of mitral stenosis. They planned to carry out the operation in two stages. At the first stage they only made the chest wall incision. At the second operation they had only opened the pleura when the patient's condition became so critical that the operation had to be stopped. At the third operation, they had gotten to the point of introducing the cardioscope when she suddenly died.

Allen[2] made an important contribution when he found that the incised valves of his experimental dogs did not heal. He followed them for eleven months and at that time it was seen that the cut edges had become epithelized but that no healing had occurred. Other workers, before and after this time, have speculated as to the possibility of the valve, once divided, later healing.

In 1923, Cutler and Levine[17] reported the first successful human case. Cutler and Beck had been working for some time in the laboratory in vain attempts to produce mitral stenosis. They then practiced dividing the dog's mitral valve leaflets with a tenotome and felt that further progress would not be made until the work was done on human patients. Fortunately, the first patient presented for operation was a girl of 11 who had severe mitral stenosis but was in fair condition. Through the interest of her physician, Dr. Maurice Fremont Smith, she was presented for operation. The operation was carried out through a Duval Barasty median thoracoabdominal pericardiotomy approach, and the tenotome introduced through the left ventricle. After exposing the pericardium, it was split along its anterior surface almost to the base of the heart and "then the posterior pericardium and diaphragm were divided together toward the suspensory ligament, thus permitting the bottom of the wound to open widely and exposing the entire heart to view and manipulation. The heart was rolled out and to the right by the left hand, the valvutome, an instrument somewhat similar to a tenotome or slightly curved tonsil knife and the one with which we were familiar in our experimental work, was taken in the right hand and plunged into the left ventricle at a point about one inch from the apex and away from the branches of the descending coronary artery where two mattress sutures had already been placed. The knife was pushed upward about 2½ inches, until it encountered what seemed to us must be the mitral orifice. It was then turned mesially and a cut made in what we thought was the aortic leaflet, the resistance encountered being very considerable. The knife was quickly turned and a cut made in the opposite side of the opening. The knife was then withdrawn and the mattress sutures already in place were tied over the point at which the knife had been inserted." The patient recovered from the operation and lived for four and one-half years with little change in her condition.

In 1925, Pribram[40] in Germany operated on a patient with mitral stenosis according to the same technique used by Cutler, but the patient died on the sixth postoperative day.

In 1925, Henry Souttar[47] of London reported in the *British Medical Journal* on a patient with mitral stenosis on whom he had successfully operated. This patient was a 19-year-old girl who had had chorea and then developed mitral stenosis. She had attacks of dyspnea and cyanosis and at times had had hemoptyses. She was admitted to the London Hospital in March, 1925, with cough, dyspnea, and pain in the limbs. There was a visible cardiac pulsation, the heart was enlarged, and there were presystolic, systolic, and diastolic murmurs. During one week's rest in bed with digitalis, the pulse rate fell from 128 to 80 and the presystolic murmur disappeared. It was thought that she had mitral stenosis and regurgitation but that she would be helped

by correcting the stenosis. Operation was carried out on May 6, 1925, under intratracheal anesthesia. A flap was turned outward with its base in the anterior axillary line, after division of the second, third, and fourth costal cartilages near the sternum, and of the ribs in the anterior axillary line. A good exposure of the heart was thus obtained. The pericardium was opened through a vertical incision medial to the phrenic nerve. The auricular appendage projected through this incision. Two sutures were passed through the upper and lower margins of the appendage.

> The auricular appendage was now drawn forward, a soft curved clamp was applied to the base and it was incised in an anteroposterior direction with scissors. Into this opening, the left forefinger was inserted, the clamp was withdrawn and the appendage was drawn over the finger like a glove by means of the sutures. The whole of the inside of the left auricle could now be explored with facility. It was immediately evident from the rush of blood against the finger that gross regurgitation was taking place but there was not so much thickening of the valves as had been expected. The finger was passed into the ventricle through the orifice of the mitral valve without encountering resistance and the cusps of the valve could be easily felt, and their condition estimated.
>
> The finger was kept in the auricle for perhaps two minutes and, during this time, so long as it remained in the auricle, it appeared to produce no effect upon the heartbeat, or upon the pulse. The moment, however, it passed into the orifice of the mitral valve, the blood pressure fell to zero, although even then no change in the cardiac rhythm could be detected. The blood stream was simply cut off by the finger, which presumably just fitted the stenosed orifice. As, however, the stenosis was of such moderate degree and was accompanied by so little thickening of the valves, it was decided not to carry out the valve section which had been arranged but to limit intervention to such dilatation as could be carried out by the finger. It was felt that an actual section of the valve might only make matters worse by increasing the degree of regurgitation, while the breaking down of adhesions by the finger might improve the condition as regards both regurgitation and stenosis.
>
> It was now decided to withdraw the finger and close the appendage. Unfortunately, at the critical moment of withdrawal, the lower retaining suture cut through, the appendage slipped back into the pericardium and there was a sudden gush of blood which, however, was instantly stopped by pressing the appendage against the heart. With a little manipulation, the tip of the appendage was now grasped between the finger and thumb which held it securely closed while an assistant passed a silk ligature around it and tied it off. The rest of the operation was without moment. The pericardium was closed, then the chest wall, without drainage.

She made an uninterrupted recovery from the operation and left the hospital in good condition. She was kept in bed in the country for six weeks and then allowed to get up. At the end of three months she declared that she felt perfectly well although she still had some dyspnea on exertion and her physical signs were unchanged.

Souttar concluded his article with the following paragraph, which seems worth reprinting.

> It appears to me that the method of digital exploration through the auricular appendage cannot be surpassed for simplicity and directness. Not only is the mitral orifice directly at hand but the aortic valve itself is almost certainly within reach through the mitral orifice. Owing to the simplicity of the struc-

tures and, oddly enough, to their constant and regular movement, the information given by the finger is exceedingly clear and personally I felt an appreciation of the mechanical reality of stenosis and regurgitation which I never before possessed. To hear a murmur is a very different matter from feeling the blood itself pouring back over one's finger. I could not help being impressed by the mechanical nature of these lesions and by the practicability of their surgical relief.*

In 1927, Geoffrey Bourne[10] of England, writing in the *St. Bartholomew's Hospital Journal* about the operations that had been performed for mitral stenosis by Cutler and Beck, and Graham and Allen, said that "it would seem that an extension of the mitral slit at its extremities is preferable to one made laterally into the cusp itself." I have found no further articles by him on this subject, but this statement of his is important, in view of the later development of the operation.

In 1929, Culter and Beck[19] made a report on their experience with the operation for mitral stenosis and summarized the ten cases of mitral stenosis that had been operated on throughout the world. Two of the ten patients recovered from their operations. The first one, operated on by Cutler in 1923, had had the valve leaflet incised. The next one was an operation in 1925 by Souttar. He had merely inserted his finger through the narrowed valve. Cutler and Beck said they thought it had been shown that resection of the valve was unsuccessful and that the changes produced might be too sudden for the patient to tolerate. They thought that the method of Souttar might be worthy of trial but I can find no record of their ever attempting his procedure. As no one had succeeded in producing mitral stenosis in the experimental animal, they felt that the basic idea of enlarging the stenosed valve by operation would have to be established by attempts on human patients.

The establishment of mitral stenosis in the dog was finally worked out in the laboratory of the Harvard Medical School by John Powers[39] when he was a resident under Cutler from 1930 to 1932. He first cauterized the valve margins by means of bipolar diathermy, the electrode being introduced through the left ventricle. After this, he injected cultures of *Streptococcus viridans* intravenously. These procedures were then repeated. In the animals that did not succumb to a bacteremia, changes in the valve were produced which were very similar to those seen in human cases of mitral stenosis. Having created the stenosis, he proceeded to test the response of the animals to resection of segments of their mitral valves. He wanted to find out if the dogs could tolerate the insufficiency so produced. All human patients subjected to this operation had died. His results with the dogs were the same as in the human cases. He made careful physiologic studies before operation and afterward. His conclusion was that the operation of resection of a mitral valve leaflet was unphysiologic and should not be used. He suggested that dilatation of the valve, as done by Souttar, might be effective, or that small

*In correspondence with Sir Henry Souttar, he wrote that if I reported his case, he wanted me to be sure to give credit to his anesthetist, Dr. J. H. T. Challis, for the important role he played.

bits of the stenosed valve might be removed in stages. Following this work, Powers went to Cooperstown, where he had no access to an experimental laboratory.

In 1945, Bailey[4] operated on a patient with mitral stenosis, expecting to bite out a piece of the mitral valve, but he tore the auricle and lost the patient from hemorrhage. In 1946, he operated on his next patient with the same object in view. He was planning to use a backward cutting instrument which he would pass through the left auricular appendage. During the operation, the stenosis was found to be so severe that he could not pass his instrument through the valve. Quoting from Bailey's letter to me,

> At that moment my medical men became a great help to me because they urged me to go ahead, to make further efforts to relieve the valvular obstruction because the rapid deterioration of the patient on the operating room table augured ill for a survival from this exploratory operation unless something definitive could be accomplished. In desperation, remembering Souttar's report, I inserted my finger through the auricular appendage, palpated the valve and pushed my finger through the diminished slit. Although the leaflets were calcified, both commissures split well and I immediately appreciated three things. One was that there was now an opening many times larger than that which had existed previously. Second, the diastolic thrill, which in this particular case was very prominent in the region of the valvular structure itself, immediately disappeared. At the same time I was unable to recognize any regurgitant jet of blood from the valve. I was quite familiar with the digital feel of the regurgitant jet from my animal experimentation. I was therefore convinced that I had both relieved the stenosis and failed to produce any regurgitation. For about twenty-four hours postoperatively, the patient's condition improved remarkably and steadily. There was no clinical evidence of regurgitation. However, one day later, she suddenly collapsed and died. From the post-mortem examination it was clearly evident that both commissures had been split and considerable mobility of the leaflets had been accomplished. It was evident from the intact suspension of the valve leaflets that regurgitation had not been produced.

Before continuing the account of the progress of Bailey's work, it is well here to refer to the work done by Horace Smithy[46] during 1948. In spite of his knowledge of the literature, and especially of the experimental work of Powers, he revived the Cutler operation, and carried out the procedure on seven patients with mitral stenosis. He differed from Cutler in that he used the auricular approach in four of the cases. One patient was operated on twice, because at the first operation, when he attempted to pass the instrument through the auricular appendage, he tore the auricle and, after controlling the hemorrhage, he abandoned the operation. Later, he used the ventricular approach with success. He concluded that the ventricular approach was the better of the two. Two of his patients died soon after operation, and one after ten months. One patient showed marked improvement during the year in which she was followed. The other three showed only slight improvement. The fact that five of the patients survived the operation was presumably due to the great improvements in anesthesia and surgical technique since the 1920's. These patients survived, and showed some improvement, in spite of

the regurgitation produced. This same operation, twenty-five years earlier, had resulted in death of six of Cutler's and Beck's seven patients, and all of Powers' experimental animals.

It was not until June 10, 1948, that Bailey was able to carry out this operation with success. On this occasion he operated on a young woman with mitral stenosis and was able to perform a commissurotomy. She recovered so promptly from the operation that it was possible to take her from Philadelphia to Chicago for the meeting of the American College of Chest Physicians within one week of the operation. She made a full recovery. Six days later, Harken[25] of Boston operated on a patient with mitral stenosis. Instead of using his finger to enlarge the valve, he used an instrument. Here is a description of the procedure he used.

> The cardiovalvutome was introduced (through an incision in the auricular appendage after three purse-string static sutures had been placed around the base of the appendage) with the cutting edge directed at the lateral commissure, the valvutome hook engaged and the instrument closed. The cutting sensation and sound were elicited but the segment was not recovered. The maneuver was repeated with the instrument directed at the medial commissure. Finally a segment of the stenotic funnel was removed in a third maneuver directed at the posterior aspect of the lateral commissure.

The patient made an uneventful recovery from the operation and, five months later, was symptomatically improved. Harken said that "the principle of increasing the size of the mitral orifice and yet producing selective insufficiency was combined with an attempt at removing the immobilizing commissures."

It is interesting that while Bailey and Harken were working in this country on the problem of the surgical relief of mitral stenosis, Russell Brock[12] in England was also planning an attack. Following his success in dividing a stenotic pulmonary valve, he decided that the same procedure could be used on the mitral valve. Remembering Souttar's article, he successfully carried out the Souttar operation on a patient with mitral stenosis in September, 1948. At this time he was not aware of the work done by Bailey and Harken. He became convinced that the operation was a sound one and carried it out on seven more patients before publishing his results in 1950. Two of his patients died after operation, but one of them died of hemorrhage, having been given heparin on the second postoperative day because of a cerebral embolus. One other patient developed a cerebral embolus but fully recovered. The other five patients had uneventful recoveries. Following this first report, he began operating on an increasingly large number of patients. He has used finger fracture in the great majority of his cases but occasionally resorts to the use of a knife to cut the commissure.

Following the reports of the work of Bailey, Glover, and O'Neil, and of Harken in this country, and of Brock in England, the operation became widely adopted. At first the mortality rates were high, but as the cardiologists changed their points of view and began referring better risk patients, the mortality rate fell. It soon became apparent that finger fracture was all that

was needed in most of the cases but in some it was necessary to use a knife to open the commissures sufficiently. Harken in this country and Brock in England have made important contributions regarding the anatomy of the mitral valve, and have pointed out the relative importance of the major and minor leaflets.

Although the present surgery of the mitral valve allows a direct attack upon the site of the trouble in mitral stenosis and seems to be the answer to the problem as it now exists, it is well to mention two other methods which have been used in treating patients with mitral stenosis. R. Lutembacher[35] in 1916 reported cases of mitral stenosis associated with auricular septal defects in which the patients lived for long times and with minimal symptoms. The septal defect kept the auricular pressure low. Because of this experience, Jarotsky[28] in 1926 suggested that auricular septal defects might be created in patients with mitral stenosis. Seneque[44] in 1926 reported that Dimitrieff had carried out the operations on dogs with success. Harken[25] in 1948 reported that he had created atrial septal defects in two patients, with recovery from the operation and improvement in symptoms. R. H. Sweet[9] in 1949 reported on his experience with the use of a venous shunt. He anastomosed the azygos vein to the dorsal segmental branch of the right inferior pulmonary vein in five patients. The results in the first three were excellent, too short a time had elapsed to evaluate the fourth, and the fifth died following a severe recrudescence of rheumatic fever. This then seemed to be a worth-while procedure but it was an indirect attack and, as commissurotomy became an established procedure, there was no further need for this operation.

During the course of the last five years, a definite classification of cases of mitral stenosis has been worked out and approved by the American Heart Association. The reporting of results of surgery for mitral stenosis must follow this classification. Very briefly, the main features of the classes are as follows: In Class 1 are those patients in whom the diagnosis is made on the basis of the characteristic murmur but without the presence of symptoms. In Class 2 are those patients with physical signs of the disease but in whom there are also symptoms. However, the patient has been able to compensate. In Class 3 are those patients who have recurring attacks of decompensation, fibrillation, and even embolization, and need constant care. In Class 4 are the patients who have progressive symptoms of heart failure with fibrillation and attacks of embolization. These patients will almost certainly die unless their stenosis can be relieved. They represent grave operative risks.

It is generally agreed that patients in Class 1 do not need operation and are not subjected to it. More and more patients in Class 2 are being operated on. The mortality for this group is usually less than 2 per cent. For Class 3, Harken[27] in 1953 reported on a group of 400 cases with a mortality rate of 2.8 per cent, whereas for Class 4, his mortality in a series of 200 cases was over 25 per cent. Glover[21] in the same year reported a total mortality for all of his patients in the different classes as 5.9 per cent in 500 cases. These figures are fairly representative for large series of cases but are undoubtedly better than can be expected for smaller series in the hands of less experienced surgeons.

One of the chief problems relating to mortality has been fatal embolism occurring during the operation. Bailey[4] felt that he could cut down on its incidence by occlusion of the innominate and carotid arteries during the operation on the valve. He reported that during the operation in 235 cases without the use of this vessel occlusion, he had 5.5 per cent embolism. In a series of 400 cases in which this occlusion was used, the incidence of embolism was less than 1 per cent. Harken expressed himself as being in favor of this maneuver, but Glover, who participated in the discussion, opposed its use. Glover felt that the vessels might be traumatized and cause cerebral anoxia.

Another important problem is the recurrence or reactivation of rheumatic fever after the operation. In Blalock's[3] series of seventy-five patients, sixty-six were studied for Aschoff bodies in the excised auricular appendage and they were found in forty. Glover[21] felt that 30 to 40 per cent of his 500 patients showed symptoms of rheumatic fever after the operation. In Harken's[27] series of 600 patients under 35 years of age, 85 per cent showed Aschoff bodies. For the patients over 45, the incidence was about 15 per cent.

PRESENT STATUS OF SURGERY FOR MITRAL STENOSIS

Although the modern operation for relief of mitral stenosis differs very little from that done by Souttar[47] in 1925, it is worth noting two technical advances. It will be remembered that in Souttar's operation, one of the sutures he had placed in the auricular appendage cut out and caused some unpleasant moments. At present, the custom is to place one or two purse-string sutures of 00 or 000 silk about the base of the appendage. This suture is usually controlled with the aid of a tourniquet holder and rarely fails to close off the appendage when the finger is withdrawn. The other change from Souttar's procedure is the use of special knives in those cases in which it is felt that complete splitting along the commissures has not been accomplished by the finger. It is generally agreed that for a satisfactory result, the commissures must be opened all the way to the myocardium. Souttar had planned to use a tenotome, as Cutler had used in his first and only successful case. Until Bailey[4] demonstrated the correctness of Souttar's ideas, everyone working on the valves of the heart had devised and used instruments with which segments of the valve leaflets could be excised. Indeed it was with such an instrument that Bailey had planned to attack the valve which he was forced to treat by finger dilatation. Bailey's first successful case was treated by finger fracture. Harken,[25] six days later, used an instrument with which he cut through the commissures. He and Bailey then devised knives with which the commissures could be cut without resecting segments of the valve. Since then, a great variety of knives have been made. It is interesting that Harken, who first used a knife, soon became the chief advocate of the finger fracture method, and Bailey came to feel that more of the valves needed to be enlarged by the use of knives. At present, most surgeons feel that the great majority of the valves can be adequately treated by finger fracture but that, when this method fails, then a knife must be used.

Of course the indications for the operation have not changed basically but they have become much more clearly defined. It is well here to quote from a recent article by Blalock[3] on this subject. He said, "There is now general agreement regarding the indications for operation: symptoms and signs of pulmonary engorgement including dyspnea of a degree limiting the patient's activity and characteristically associated with cough, paroxysmal nocturnal dyspnea, attacks of pulmonary edema after exertion or at rest, and hemoptysis." The contraindications are also quite generally agreed upon but there are more individual variations. Again quoting Blalock, he stated that bacterial endocarditis is the most obvious but fortunately is the least frequent contraindication. Associated aortic valve disease is important and one must evaluate the possible effects upon it of opening the mitral valve. Especially when there is a considerable degree of stenosis, this might promote regurgitation of blood back through the mitral valve during ventricular systole. Intractable right heart failure is a special contraindication and, when present, is associated with a high mortality. Acute rheumatic disease, so far as it can be recognized, is a definite contraindication. Blalock felt that operation should not be performed in the presence of elevated erythrocyte sedimentation rate. Finally, there is general agreement that when insufficiency is the dominant abnormality of the mitral valve, commissurotomy should not be performed.

COMMENT

The one unexplained fact in the history of the development of an operation for mitral stenosis is the failure of other surgeons to repeat Souttar's operation until 1948. In retrospect, it seems incredible that he himself did not continue his work, and that the men in this country who had done so much work on surgery of the heart did not recognize its value.

The explanation for Souttar's failure to continue his work is simple. He had no more patients referred to him for operation. And yet, he was Director of Surgery of the London Hospital, and one of the leading surgeons in England at the time. However, Sir James Mackenzie was the leading cardiologist of that time, and had a profound influence over other cardiologists in England, and even in this country. He believed that the chief feature of mitral stenosis was the diseased myocardium, and that the stenosed valve was of secondary importance. So he was opposed to operation for relief of the stenosis. And this opposition prevented Souttar from continuing his work.

In this country, there was the same general opposition to surgery for mitral stenosis. Even Dr. Evarts Graham was unable to persuade his medical colleagues of the value of operation. In Boston, Dr. Samuel Levine stood out in opposition to Sir James, and was responsible for Cutler being able to operate on some seven patients with mitral stenosis. Why then did not Cutler and Beck follow Souttar's lead? We shall never know why Cutler failed to do so, but Beck has stated, in a letter to me,[6] and in an article[5] in the *Journal of the American Medical Association,* his reason for not adopting the operation. He believes that there has been a change in the character of the mitral

valve as a result of the use of sulfonamides and antibiotics. The hearts he studied in the pathology laboratory in the 1920's had valves that were calcified and so tough that he does not believe finger fracture could have been used. In this connection it must be remembered that in Souttar's case he did not fracture the valve with his finger. He merely placed his finger through the valve, and was assured of its patency by so doing. He probably was not aware of the possibility of actually fracturing the valve, although he was sure that the stenosis could be corrected by passing his finger through it.

It is interesting to hear the comment of Dr. Samuel Levine who worked with Cutler and, with him, reported the first successful case of surgery for mitral stenosis. He wrote,[34] "The fact that no further case reports or experiences were recorded indicated that nothing very much had been accomplished. I do recall that the criticism on the part of the leading authorities at that time, particularly Sir James Mackenzie, was that it was useless to attack the valve because that was not important. Mackenzie thought that the all-important part was the myocardium and that would not be altered by surgery of the valve. In fact, he wrote me just to that effect, after Cutler and I had published our first case. I was certain even then, and have felt the same way ever since, that the valvular defect was all-important in rheumatic heart disease." He also stated that he did not believe there had been any change in the character of the valve. He felt that our surgery was just not sufficiently advanced at the time. When one recalls that lobectomy carried a mortality rate of around 45 per cent at that time, his comment seems reasonable.

Another reason for the failure of American surgeons to adopt the Souttar operation has been well expressed by Dr. Evarts Graham.[23] He wrote, "When I heard about Souttar's case, I was, of course, much interested but felt that his procedure would never amount to very much because it lacked precision and was a blind one. It had always been my feeling that in surgery, one of the first rules is to have exposure so that you can see exactly what you are doing."

So, for one reason or another, twenty-three years passed after Souttar's operation before it was tried again. And then, within a period of three months, in widely separated places in the world, his operation was revived. The time was not ripe in 1925. It was in 1948.

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Appraisal of Progress in Surgical Therapy

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TREATMENT OF LACERATED WOUNDS

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SO MANY excellent discussions on the treatment of open wounds have been presented in the past few years[1-6] that the addition of another demands some justification beyond the fulfillment of a promise to friendly, if sometimes insistent, editorial boards. If such a contribution can be justified, it must be on the grounds that simple surgical principles need constant repetition, both because new generations of medical students and surgeons need help and guidance, and because today, as so often in the past, false prophets would have us believe that the time-honored principles of surgical care have lost some of their validity and importance in the new era that began with the introduction of local and parenteral chemotherapy. It does not require an unusually retentive memory to recall the promise that a new "Therapia sterilisans magna"[7] would solve the ever-present problem of local and systemic infection, or the sweeping conclusion that the local application of a sulfonamide to open wounds would render obsolete previously employed and time-tested methods of surgical care of wounds.[8] So overwhelming was the wave of enthusiasm for sulfonamide therapy at the beginning of World War II that the local application of sulfanilamide and sulfathiazole both in external wounds and in the peritoneal cavity was frequently advocated and widely employed. So unreservedly were such recommendations made and accepted that at a meeting of the American College of Surgeons in Boston in October, 1941, the still small voices of Mason and Allen were scarcely heard as they reported the results of implantation of sulfonamides in experimental animals undergoing tendon repair and tendon transplantation. The hemorrhagic exudation and delayed healing that resulted from such implantation were rather promptly recognized and confirmed by the workers who were making carefully controlled studies of different methods of treatment of wounds and burns under the sponsorship of the Subcommittee on Wounds and Burns of the National Research Council.[9] Still later, the failure of local applications of sulfonamides or antibiotics to control infection in open wounds or to stimulate healing became widely recognized, but, in spite of that fact, the use of such local applications still continues and extravagant claims for the beneficial effects of medicated creams, ointments, and jellies constitute a

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sizable proportion of the surgeon's daily mail. The basic fact that wound healing is a function of living tissues, and is not hastened or stimulated, but often retarded, by any chemical agent applied to their surface, is forgotten still too often.

Any discussion of actual treatment must begin with "first aid," for success or failure is often determined by the care that is given the patient immediately after the injury has been sustained. One can say categorically that the best first aid is immediate covering of an open wound with a sterile dressing, or, lacking that, a clean towel or pillow case, *not* a pocket handkerchief; the application of a compression bandage to control bleeding; and an immobilizing splint. Bleeding can almost always be controlled by a compression bandage reinforced, if necessary, by firm manual pressure directly over the dressing. Persistent oozing can be arrested by elevation of the limb.* Rarely is a tourniquet necessary; and the harm that can result from the pressure of a tourniquet applied by an eager "expert" in first-aid care can far outweigh the importance of the possible blood loss.

As first-aid instruction, every foreman in our large industrial plants and every Boy Scout might well have pasted in his cap these simple directions: "Cover the open wound with a sterile dressing. Apply a compression bandage. Hold pressure over it, and keep it at rest."

At the entrance to every modern Emergency Room is a container with face masks. Perhaps there should also be a warning, "No bacteria wanted." Today the emergency room where patients with open wounds and burns are first seen is guarded against foreign invaders—pathogenic bacteria—as carefully as the modern operating room.

It is unnecessary to repeat the essential and accepted procedures that the surgeon carries out in the preliminary care of wounds: a quick survey of the patient's condition, an examination sufficient to determine the probable extent of injury, whether an x-ray examination is indicated, and whether the patient should be hospitalized.

It is likewise unnecessary to describe what we and many others consider the most satisfactory method of converting an open wound into a clean surgical wound: soap and water cleansing with gloved hands and large sponges of sterile cotton, plain white soap, and sterile warm water. It is our belief that no other method is quite so effective or causes so little trauma to the vulnerable tissues exposed in an open wound.

The time factor, the extent and character of the injury, the structures involved, the patient's condition, and his ability to undergo what may be a prolonged surgical procedure all demand consideration. These again have been discussed so often and in such detail that one does not feel justified in repeating what is common knowledge readily available to every reader.

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*"When the patient is first seen no attempt is made to do anything to the wound except to control hemorrhage, if this is necessary. We prefer to do this by placing firm pressure on the wound with the hand, through the medium of a sterile dry sponge, while at the same time elevating the part. If there is a rather large active bleeder, this can often be stopped by direct pressure with the point of the finger until a ligature or clamp can be applied to it. Sometimes, mediate pressure with the finger on the main artery away from the wound will accomplish the same thing. We prefer, if possible, never to use the tourniquet simply for the emergency control of hemorrhage, unless upon so badly mangled extremities that they must obviously be amputated."[1]

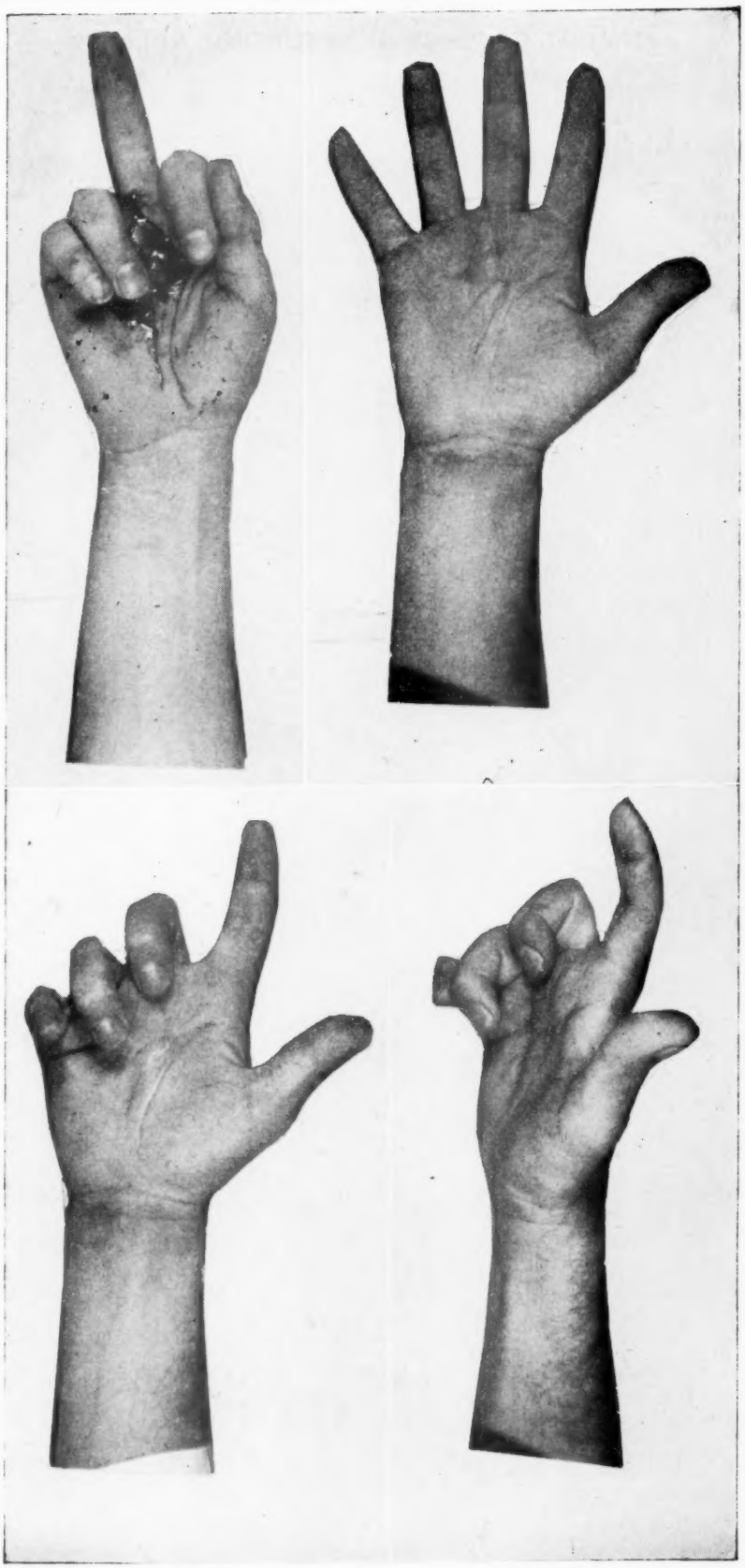

Fig. 1.—Glass cut of palm with division of superficial palmar arch and flexor tendons of middle finger (the digital nerves escaped injury). Soap and water cleansing, tendon suture, wound closure without drainage two hours after injury. No sulfonamides or antibiotics were given. Healing by primary union. *A*, Appearance on admission; *B*, *C*, and *D*, result 6 weeks later.

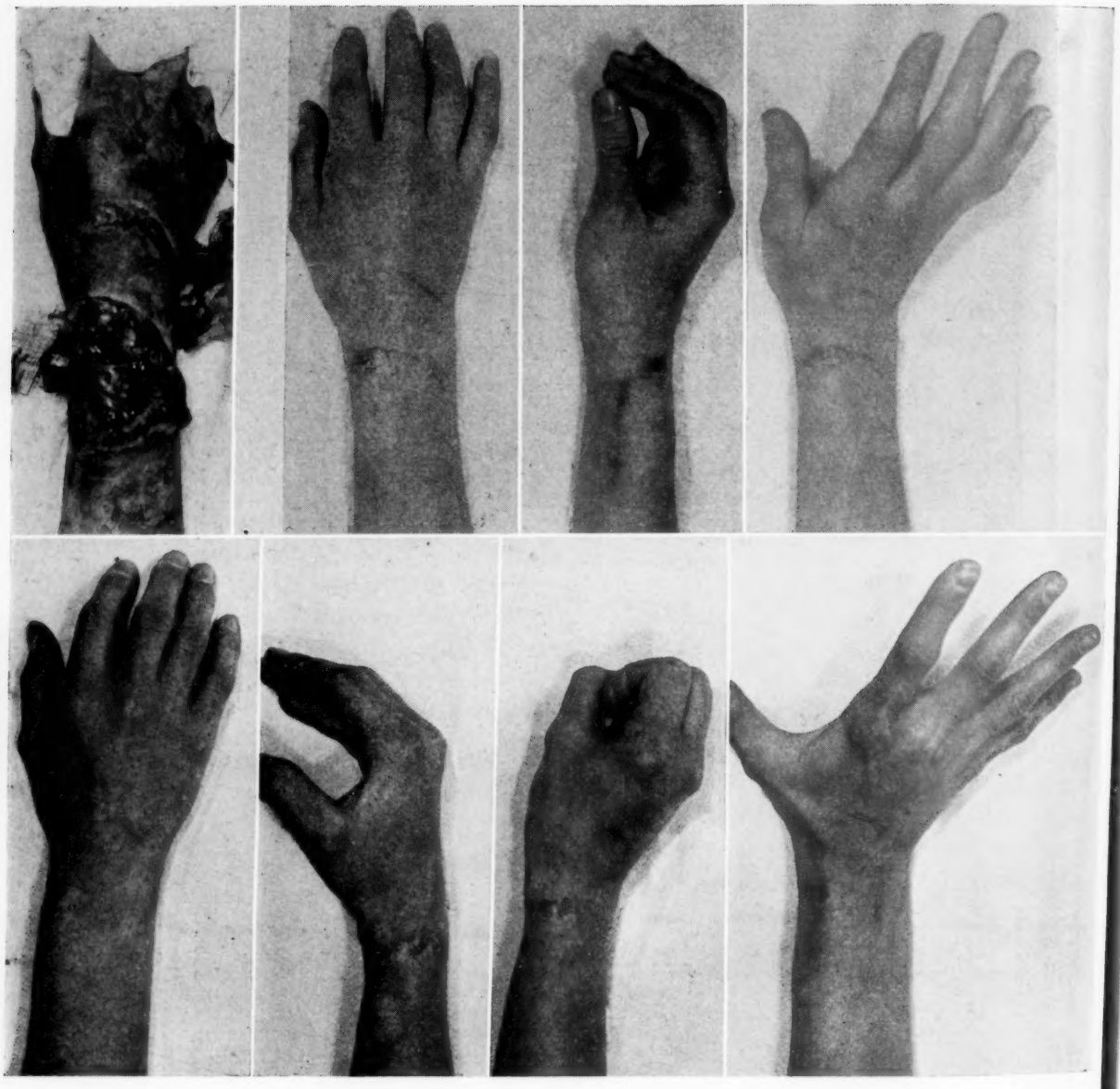

Fig. 2.—(Patient of Dr. Michael Mason.) Glass cut (from broken storm window) of forearm, with division of extensors of index, middle, and ring fingers in distal wound, division of radial nerve, of extensors of radius and short extensor of thumb in proximal wound. Soap and water cleansing, repair, wound closure five hours after injury. 300,000 units of penicillin given daily during 7-day hospital stay. Primary wound healing. Above: Appearance on admission and 6 weeks later. Below: Result 3½ months after injury.

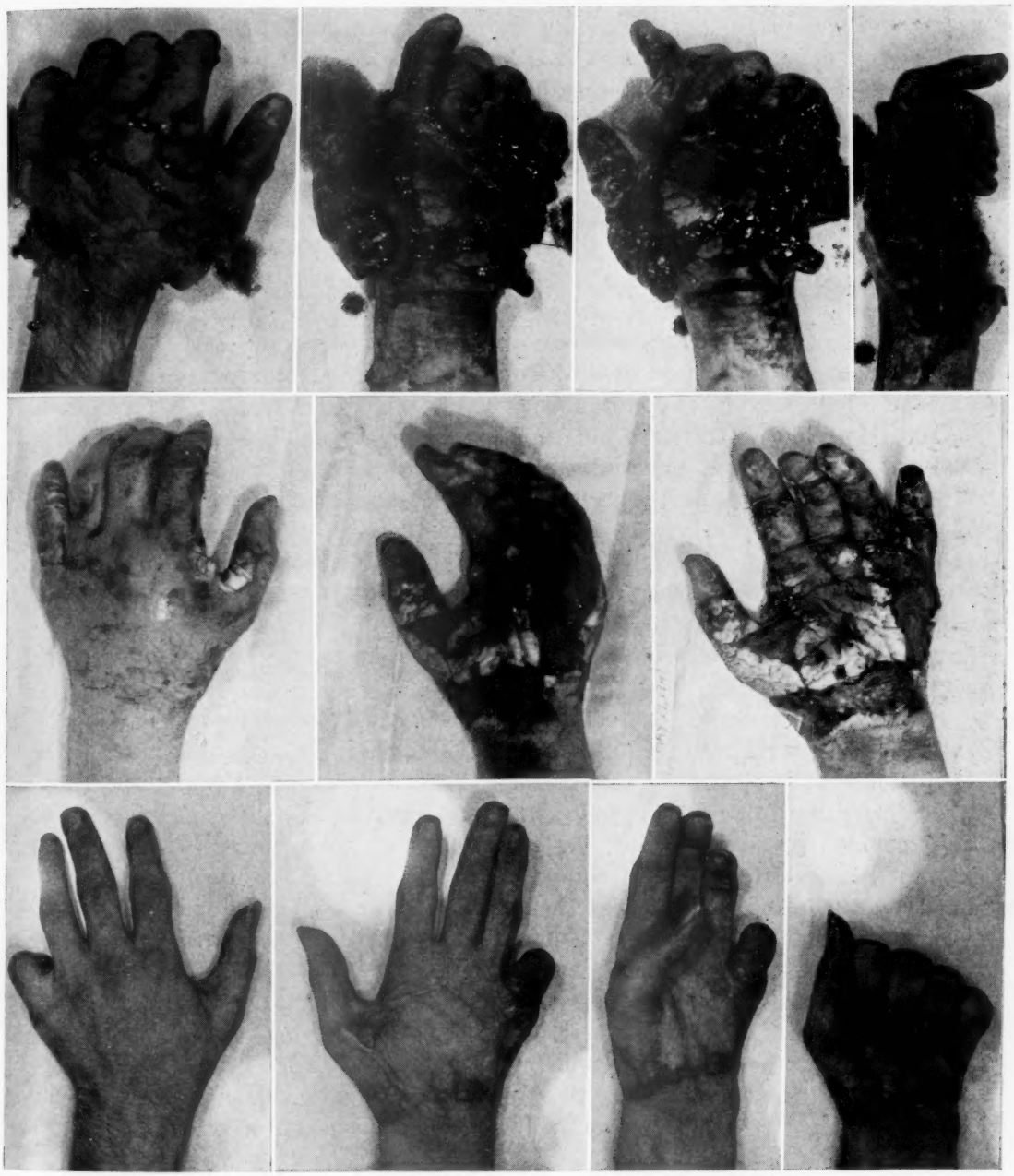

Fig. 3.—(Patient of Drs. Michael Mason and Harvey Allen.) Injuries resulting from explosion of bomb made in college laboratory. Patient was seated in automobile, holding bomb in lap. He sustained equally severe wounds of right hand and multiple lacerations of face and thighs. Patient received 50,000 units of penicillin every 3 hours during 12-day stay in hospital.

Upper row: Appearance of left hand on admission eight hours after injury. Middle row: Appearance 11 days after wound repair, which included use of multiple skin grafts. Lower row: Result 6 months later.

The importance of good surgical technique in reducing the fractures that are not infrequently associated with lacerated wounds, of repairing divided nerves and tendons, of closing wounds without tension, and with the aid of skin grafts or of flaps when covering tissue has been lost cannot be overemphasized. The value of a compression dressing, of splinting to provide rest for the injured part, and of elevation to prevent congestion and favor the return circulation are well recognized.

One problem concerning which there are conflicting opinions today concerns the routine use of antibiotics. With the passing months, it has become increasingly apparent that the antibiotics are not the unmixed blessing it was hoped for. As has happened so often in the past remedies that were heralded with enthusiasm as harbingers of a new era and that for a time gained wide acceptance proved eventually to be without value or to cause serious and unexpected complications that almost nullified their value. Today Mercurochrome is almost forgotten; sulfathiazole and sulfadiazine are remembered best by those who had to face the problems of ureteral obstruction, anuria, agranulocytosis, and toxemia that too often followed the prolonged and indiscriminate use of these drugs. With increasing frequency, reports of serious allergic reaction following the use of penicillin are appearing in the surgical literature.[10] At the same time, more and more instances are being recorded of infection due to penicillin-resistant organisms. The phenomenon of so-called superinfection, infection due to pathogenic organisms that play a minor role until the inhibitory effect of penicillin-sensitive organisms is removed, introduces a new aspect of the problem of controlling infection.[11]

It would seem logical and sensible, as has been advocated by many thoughtful observers, to restrict the use of antibiotics to cases with definite indications. In patients with clean lacerated wounds due to glass cuts, sustained indoors under clean conditions (as opposed to wounds sustained on the street or in a meat or food processing plant, for example), and given correct first aid and prompt surgical treatment, it would seem wise to omit the use of antibiotics until some definite indications for their use—fever or local signs of inflammation —develop. One cannot forget that surgeons consistently secured healing by first intention in open wounds properly cared for before penicillin and other antibiotics were available. The same methods of surgical care are equally available today.

To sum up the matter, I would like to quote from what I have always considered the "master word" on the treatment of wounds, Mont Reid's classic paper entitled "Some Considerations of the Problems of Wound Healing."[12]

> Pasteur's work told the world what was causing the infection of wounds and unloosed . . . a veritable flood of bactericidal agents which show no signs of abating even today. Paré astounded himself and the surgical profession of his time when he learned that the sloughing incident to the buring of wounds with boiling oil or the actual cautery had a very deleterious effect upon the healing of wounds. He learned that the gentlest cleansing of the wounds with the commonest innocuous substances at his disposal at that time, such as water and soap, gave the best wound healing. Today, with our knowledge of the delicacy of growing living cells and of their lethal susceptibility to alcohol, ether, iodine, mercurochrome,

merthiolate, carbolic acid, bichloride of mercury, and countless other substances, people go blithely on pouring them into open fresh wounds to kill living cells and to complicate the process of wound healing and to promote the chances of infection. So far as fresh traumatic wounds are concerned we would today be far better off with a total ignorance of all chemical bactericidal agents and if we only utilized our knowledge of bacteria and of wound healing by gentle mechanical cleansing of all the surrounding skin and open wound of all dirt, foreign bodies, dead or devitalized tissue and by flooding the invisible bacteria away by means of sterile salt solution. Paré was, in the light of modern knowledge, densely ignorant, but he acted with amazing sanity; today, with a colossal knowledge of the properties of both bacteria and living cells, many wounds are being treated with a lack of sound judgment.

That "sound judgment" can come from a thoughtful consideration of the conditions present in the individual case and a steady adherence to basic principles of good surgery.

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Erratum

In the article by Robert E. Rothenberg, M.D., and Theodore Barnett, M.D., entitled "Bilateral Herniotomy in Infants and Children," which appeared in the June, 1955, issue of the JOURNAL, pages 947-950, the following corrections should be made: On page 949, in the third paragraph of text material, in line 3, "8 of 9 children" should be substituted for "8 or 9 children"; in line 5, "5 of 8 children" should be substituted for "5 to 8 children."

Book Reviews

Die Wirbelsaulen-Verletzungen und Ihre Ausheilung. By Alfons Lob. Pp. 272, with 149 Illustrations, 340 Drawings, 16 Tables. Enlarged Ed. 2. Stuttgart, 1954, Georg Thieme.

The appearance of the second edition of Dr. Lob's book on *The Injuries of the Vertebra and Their Healing* comes at a time when the pendulum is swinging from the more radical types of treatment of these injuries to the more conservative methods. Fifteen years ago compression fractures of the spine, particularly the lumbar spine, were almost all treated by reduction in hyperextension with prolonged immobilization by means of plaster dressings and braces. The impetus to this method of treatment was given largely by Davis and Bohler. More recently, because of a dissatisfaction with the late results in individuals treated in this manner, and because of the prolonged morbidity involved in this method of treatment, the general management of most of these fractures has become more conservative. That is, little effort is made to reduce the fracture, patients are urged to become active early with the institution of hyperextension exercises, and of light supports, if any.

This book consists of a study of the gross pathology of patients with fractured spines and a careful comparison of the x-ray photographs of these patients. Two particular varieties of vertebral injury are discussed thoroughly. These are: (1) the isolated injury involving only the bony structure of the vertebra, and (2) injuries of the vertebra with protrusion of the intervertebral disc and disruption of the superior or inferior plate of the vertebral body.

In the first case, bony healing is rapid and complete. In the second case, because of the large gross interposition of portions of the disc in the crushed area, healing is more frequent by fibrous union.

The author clearly demonstrates that although reduction of the collapsed vertebra can be accomplished by hyperextension as judged by the x-ray pictures, examination of the bone itself reveals that the disrupted disc is not returned to its proper relationship and that the reduced position can hardly be maintained.

The author calls attention to numerous studies which show that only a very small per cent of all vertebral fractures reduced by hyperextension maintain their position after two or three years.

By his careful examination of the pathologic specimens and their correlation with the x-ray findings, the author presents a work of exceptional interest; the chief conclusion to be drawn from his material is that the hyperextension treatment of fractures of the vertebra does not give a result more satisfactory than the conservative treatment which involves much less morbidity and discomfort for the patient.

Surgeons and orthopedists treating spine fractures will find this a most refreshing and informative monograph.

Manual of Hand Injuries. By H. Minor Nichols. Pp. 352. Chicago, 1954, The Year Book Publishers, Inc. $6.00.

This will be a very useful book for all physicians, especially those who encounter hand injuries only rarely. The best features of the book are its compactness and its low cost, which will make it possible for the interns and residents to acquire it without undue hardship. The material in the book is not new but it is well presented in a systematic

manner. It provides many useful technical suggestions for the management of hand injuries of all varieties and degrees. The diagrams and illustrations are very straightforward and easy to understand. This book is not meant for the library but rather for the emergency room and for the operating room, wherever the initial treatment of hand injuries is undertaken. The author addresses himself essentially to medical students, interns, residents, and practicing physicians. He has succeeded in putting together a very valuable working tool which should find wide circulation.

SECOND CONGRESS OF THE INTERNATIONAL SOCIETY OF ANGIOLOGY, LISBON, PORTUGAL, SEPT. 18-20, 1953

EDITED BY HENRY HAIMOVICI

1. Symposium on Mitral Valvular Surgery.
2. Angiology Forum. Imprimerie médicale et scientifique (S.A.), Brussels, 1954.

The Second Congress of the International Society of Angiology, which was held at Lisbon in September, 1953, was presided over by an American surgeon, Dr. Emile F. Holman of San Francisco, and was attended by members from twenty-six different countries, including Canada, the United States, and countries of Europe and South America. The report of the proceedings demands the respectful consideration of all who are interested in this new and rapidly advancing branch of surgery. The introductory remarks by the president described the progress in this field since Gross's successful ligation of a patent ductus in 1938 in the happy phrase, "a steady march into the unknown." Certainly the most optimistic surgeon, a decade and a half ago, could scarcely have envisaged the achievements recorded in these transactions.

An entire day of the conference was given over to the discussion of mitral valvular surgery. Thirteen of the papers dealt with mitral stenosis and covered all its phases: physiology, pathology, clinical findings, indications and contraindications for surgery, including the hemodynamic criteria of selection, surgical techniques, and postoperative results. There was necessarily a certain amount of overlapping, but there is considerable value in the repeated emphasis upon such a vital consideration as the careful selection of cases as the key to successful results.

There is general agreement that operation is never indicated in asymptomatic mitral stenosis. Auricular fibrillation is not a contraindication, and a history of embolism is an indication for surgery rather than a contraindication. Acute rheumatic fever is a contraindication, but a low-grade fever and moderate elevation of the sedimentation rate do not necessarily contraindicate operation. Total calcification is a contraindication. So are severe cardiac failure and gross hepatomegaly. The age limits for surgery are gradually rising. The series of more than 1,000 cases presented by Bailey and his associates included a child of 3 years of age and a man of 61.

The increasing number of cases in which operation was performed instrumentally rather than digitally is typical of current trends. Santy and his associates used the knife in forty-five of their last 127 cases, and Bailey and his group employed this technique in 62.5 per cent of their cases.

In all, more than 1,600 surgical cases of mitral stenosis were reported, with a mortality rate ranging from 6.6 to 14 per cent. When the various series are examined, the decreasing mortality in all recent cases is impressive. Dogliotti, for instance, one of whose patients was 60 years of age, lost six patients in his first fifty operations, three in the second fifty, and one in the last fifty.

End results are also extremely encouraging. Brock followed up 135 patients for one to five years, and while three were dead and three had relapsed, most of the other 129

patients had maintained excellent improvement. Bailey and his group followed 502 patients for six months to six years. More than 90 per cent had had results which could be classed as satisfactory and more than one-half were greatly improved.

Worthy of special mention is the film, with commentary, on the function of the mitral valve, which was presented by Hurwitt. It demonstrated that there are two components to mitral valvular function, the muscular and the hydrodynamic. The large proportion of the closure contributed by the valve ring action has hitherto not been appreciated and may explain the improvement that frequently follows mobilization of stenotic cusps in mitral valvular insufficiency.

Of the three papers on the surgical treatment of mitral insufficiency, the most important was by Bailey and his group. These observers, who reported the first operations for this condition in 1951, reported 257 additional operations. The techniques described are ingenious, and in the expert hands of this group they apparently produce good results, but the mortality rate will probably always be higher in these cases than in mitral stenosis. Chalnot and his associates described a technique for the treatment of mitral insufficiency by means of a plastic prosthesis. The experimental results were encouraging, but one wonders whether it is wise to place a permanent plastic prosthesis in the cardiac cavity.

There are three papers on arterial thrombosis. In an experimental study, Haimovici showed that when stenosis from this cause affects 60 per cent or less of the diameter of the artery, only insignificant changes occur, which are limited to the blood pressure. When, however, the involvement rises to 70 per cent, a critical stage is reached. A similar mechanism may exist in man, with the preocclusive stage lasting for long periods without any clinical evidence of what is occurring. This is a valuable contribution. Too little attention has been paid in the past to the hemodynamics of peripheral vascular occlusion. In the second paper in this group, Wylie reviewed thromboendarterectomy in sixty-two patients; fifty-four were still alive and forty-seven were in good condition. There were only seven deaths in the whole series, none of them in the last seventeen patients. This operation may well continue to have a place in the management of arterial disease, in spite of the advances made in the last two years in the use of grafts. The third paper in the group dealt with the surgical management of stenosis of the femoral and the iliac arteries.

In one of the two papers on replacement of resected segments of arteries by grafts, Hurwitt reported an experimental study designed to show that certain nonexpendible arteries may be replaced by those which are expendible; the advantage of this technique is that autogenous grafts are already attached at the aortic end. The incidence of thrombosis was high in the experimental animals, but it may be that it would be less in the larger arteries of the human subject. The report on homologous grafts by Julian and his associates is now far exceeded by DeBakey's large series. The authors raise the question whether resection and grafting is ever justified in thrombotic occlusions. When obstruction of the artery is incomplete, the answer would seem to be "no."

Diez and Ferrando's suggestion that the popliteal vein be resected in the acute period of postphlebitic sequelae, to prevent embolism, seemed open to question. The other paper on the postthrombotic syndrome, by Linton, was an extensive report. The importance of the so-called venous heart in the pathogenesis of ulceration was emphasized. Of forty-one ulcerated extremities treated surgically, 92 per cent were healed at the end of a follow-up covering from four to nine years. There were fourteen recurrences, but only four were of a major nature, and all of them could be attributed to the patients' own carelessness; they permitted themselves to become obese, and they did not wear the recommended supports. Surgical techniques included: (1) removal of the superficial venous system of the affected limbs; (2) interruption of the deep venous system by ligation and division of the superficial femoral vein at its junction with the profunda

femoris; (3) interruption of the communicating veins on the inner and posterior aspects of the lower leg below the knee; and (4) resection of the deep fascia as in the Kondoleon operation for chronic lymphedema.

Leriche, the father of sympathetic nerve surgery, reviewed basic physiologic facts and pointed out the questions which still remain unanswered in this field. He warned again that animal experiments are not entirely applicable to human subjects. Of practical importance is his suggestion that more lasting effects are accomplished if preganglionectomy is used in the upper extremity. He doubts that extension of the length of the sympathectomy will increase the effectiveness of the operation. Fragosa recommended sympathectomy before amputation, on the ground that more conservitive amputation is thus made possible. There is not much to be said for Stoyanovitch's advocacy of removal of the third left sympathetic ganglion for a wide variety of conditions, including oblitertive endarteritis of the lower extremities and polyarthritis.

Other papers covered serial aortography; the use of Danilone (phenylindanedione) in thromboembolic disorders; Martorell's syndrome, which, at least in its variants, is perhaps more common than it is believed to be; the etiology of pericarditis; a clinical and experimental study of the surgical treatment of angina pectoris by resection of the preaortic plexus, a procedure that to date has won little acceptance in spite of Arnulf's reported good results in a limited number of cases; and a study of cardiac septal defects by Shumacker, which showed that the management of ventricular defects is still a major problem without final solution. Kinmonth's study of the lymphatics in idiopathic lymphedema is important work in a somewhat neglected field. The author concludes that excision and grafting are more effective than surgery planned to create new channels.

As this necessarily brief summary shows, this is an important compilation of studies in a relatively new and extremely important surgical field. The transactions of the second meeting augur well for the future of the International Society of Angiology.

Books Received

The receipt of books is acknowledged in this section and this treatment must be regarded as sufficient acknowledgment of the courtesy of the senders. Selections will be made for more extensive review dictated by the interest of our readers as space permits.

DER HERZKATHETERISMUS BEI ANGEBORRNEN UND ERWORBENEN HERZFEHLEN. By Drs. O. Bayer Loogen, and H. H. Wolter, 191 Seiten, 131 Abbildungen, Gangleinen. Pp. 191, with 131 illustrations. Price $8.60. Stuttgart, Georg Theime Verlag, Agent for U. S. A.: Grune & Stratton, Inc., New York, N. Y.

CLINICAL ORTHOPAEDICS. No author listed. Pp. 230. Price $5.00. Philadelphia, J. B. Lippincott Company.

DIE NARKOSE EIN LEHR UND HANDBUCH. By Profs. Dr. H. Killian, and Dr. H. Weise. Pp. 1003, with 328 illustrations. Price $40.50. Stuttgart, Georg Theime Verlag, Agent for U. S. A.: Grune & Stratton, Inc., New York, N. Y.

ATLAS POSTMORTALER ANGIOGRAMME. By Prof. Dr. J. Schoenmackers, and Dr. H. Vieten. Pp. 203, with 36 illustrations. Price $73.55. Stuttgart, Georg Theime Verlag, Agent for U. S. A.: Grune & Stratton, Inc., New York, N. Y.

EINRICHTUNG UND ARBEITSWEISE EINER BLUTBANK. By Dr. Habil W. Heim, and Prof. Dr. Habil P. Sahr. Pp. 328, with 36 illustrations. Price $7.85. Stuttgart, Georg Theime Verlag, Agent for U. S. A.: Grune & Stratton, Inc., New York, N. Y.

ANTIBIOTIKA FIBEL. By Dr. A. M. Walter, and Prof. Dr. L. Heilmeyer. Pp. 813. Price $18.80. Stuttgart, Georg Theime Verlag, Agent for U. S. A.: Grune & Stratton, Inc., New York, N. Y.

THE SURGERY OF PULMONARY TUBERCULOSIS. By Dr. James H. Forsee, Fitzsimmons Army Hospital, Denver, Colorado. Pp. 208, with 59 illustrations. Price $6.50. Philadelphia, Lea & Febiger.

THORAKOSKOPISCHE EINGRIFFE AM NERVENSYSTEM. By Dr. E. Kux, and Prof. Dr. B. Breitner, Der Universitat Innsbruck. Pp. 130, with 48 illustrations. Price $28.50. Stuttgart, Georg Thieme Verlag, Agent for U. S. A.: Grune & Stratton, Inc., New York, N. Y.

ANATOMY OF THE BRONCHOVASCULAR SYSTEM; ITS APPLICATION TO SURGERY. By Dr. G. L. Birnbaum, Chief, Surgical Unit, Veterans Administration Regional Office, Portland, Ore. Pp. 300, with 99 illustrations. Price $15.00, Chicago, The Year Book Publishers, Inc.

ANESTHESIA IN GENERAL PRACTICE. By Dr. S. C. Cullen, Chairman, Division of Anesthesiology, Department of Surgery, State University of Iowa Hospital. Ed. 4. Pp. 312, with 37 illustrations. Price $5.00. Chicago, The Year Book Publishers, Inc.

MANUAL OF PROCTOLOGY. By Dr. Enid Granet, Lecturer, Graduate School, Columbia University. Pp. 346, with 119 illustrations. Price $7.50. Chicago, The Year Book Publishers, Inc.

ANATOMY OF THE HUMAN BODY. By Dr. Henry Gray. Edited by Charles M. Goss, Managing Editor of the Anatomical Record, Professor of Anatomy, Louisiana State University School of Medicine, New Orleans. Ed. 26. Pp. 1480, with 1,202 illustrations. Price $16. Philadelphia, Lea & Febiger.

DIE CHIRURGIE DER BAUCHSPEICHELDRÜSE. von Prof. Dr. Gerhart Jorns, Leitender Arzt des Stadtischen Krankenhauses, Arnstadt, Thuringen. Pp. 144, with 34 illustrations. Price $19.80. Berlin, Walter de Gruyter & Co.

JAILBIRD. Susan Vincent, R.N. Pp. 155. Price $3. New York, Vantage Press, Inc.

FUNKTIONELLE RONTGENDIAGNOSTIK DER HALSWIRBELSAULE. By Dr. C. Buetti-Baüml, Basel 1954, VIII. 160 Seiten, 154 Abbildungen, Gangleinen, D.M. 42. Pp. 160, with 154 illustrations. Stuttgart, Georg Thieme Verlag, Agent for U. S. A.: Grune & Stratton, Inc., New York, N. Y.

THE BACTERIAL FACTOR IN TRAUMATIC SHOCK. Dr. J. Fine, Department of Surgery, Beth Israel Hospital, Harvard Medical School, Boston. Pp. 82, with 3 illustrations. Price $2.75. Springfield, Charles C Thomas, Publisher.

FLUID BALANCE IN SURGICAL PRACTICE. By Dr. L. P. LeQuisne, Assistant Director, Department of Surgery, Middlesex Hospital. Pp. 130, with 41 illustrations. Price $3.50. Chicago, The Year Book Publishers, Inc.

BABCOCK'S PRINCIPLES AND PRACTICE OF SURGERY. Edited by K. C. Jonas, Superintendent of Surgery, Temple University School of Medicine, Philadelphia. Ed. 2. Pp. 1,543, with 1,006 illustrations. Price $18. Philadelphia, Lea & Febiger.

AN OUTLINE OF PRESENT DAY THORACIC SURGERY. By Dr. Robert L. Carlson, Veterans Administration Hospital, Nashville. Pp. 150. St. Louis, Educational Publishers, Inc.

NECK DISSECTIONS. By Dr. J. B. Brown, Professor of Clinical Surgery, and Dr. F. McDowell, Assistant Professor of Clinical Surgery, Washington University, St. Louis. Pp. 163, with 82 illustrations. Price $7.50. Springfield, Charles C Thomas, Publisher.

PROGRESS IN CLINICAL SURGERY. By Dr. R. Smith, St. George's Hospital, London, England. Pp. 414, with 112 illustrations. Boston, Little, Brown & Company.

RETROPUBIC PROSTATECTOMY. By Dr. Francis A. Beneventi, New York Hospital, New York. Pp. 227, with 74 illustrations. Springfield, Charles C Thomas, Publisher.

KRANKENGYMNASTIK IN DER CHIRURGIE. By Prof. Dr. Wolfgang Kohlrausch. Pp. 101, with 35 illustrations. Berlin, Walter de Gruyter & Co.

ATLAS OF HUMAN ANATOMY. By Dr. F. Frohse, and M. Brodel. Pp. 88. Price $2. New York, Barnes & Noble, Inc.

YEAR BOOK OF GENERAL SURGERY. Edited by Dr. E. A. Graham, Barnes Hospital, St. Louis. Pp. 500, with 131 illustrations. Chicago, The Year Book Publishers, Inc.

ANATOMY OF THE BRONCHIAL TREE. By Dr. R. C. Brock, Brompton Hospital, London, England. Ed. 2. Pp. 243, with 157 illustrations. Price $11. New York, Oxford University Press.

LA VALVOLA MITRALE. By Dr. M. A. Chiechi, Rome. Pp. 561, with 158 illustrations. Rome, Tariffa Ridotta Editori, Roma.

SURGERY OF THE ELBOW. By Dr. F. M. Smith, Orthopedic Surgery, Columbia University, New York. Pp. 340, with 153 illustrations. Springfield, Charles C Thomas, Publisher.

STELLATE GANGLION BLOCK. By Dr. D. C. Moore, Virginia Mason Hospital, Seattle, Washington. Pp. 280, with 153 illustrations. Springfield, Charles C Thomas, Publisher.

NERVE BLOCKS. By Dr. John Adriani, University of Louisiana, New Orleans. Pp. 265, with 168 illustrations. Price $6.50. Springfield, Charles C Thomas, Publisher.

HERZKRANKHEITEN IM SAUGLINGSALTER. By Priv. Doz. Dr. Ettore Rossi, Zurich. Pp. 373, with 198 illustrations. Price $15.45. Stuttgart, Georg Thieme Verlag, Agent for U. S. A.: Grune & Stratton, Inc., New York, N. Y.

KLINISCHE FEHLDIAGNOSEN. By Prof. Dr. M. Bürger, Direktor der Med. Universitatsklinik, Leipzig. Pp. 550, with 214 illustrations. Price $14.75. Stuttgart, Georg Thieme Verlag, Agent for U. S. A.: Grune & Stratton, Inc., New York, N. Y.

FLUID THERAPY. By Dr. J. S. Hardy, University of Tennessee, Memphis. Pp. 255, with 77 illustrations. Price $5.50. Philadelphia, Lea & Febiger.

HERNIA. By Dr. C. B. McVay, University of South Dakota. Pp. 40, with 19 illustrations. Price $4.75. Springfield, Charles C Thomas, Publisher.

COMMON DISEASES. By Dr. W. R. Bett, London. Pp. 334. Price $4. Oklahoma, University of Oklahoma Press.

CLINICAL ORTHOPAEDICS. Editor-in-Chief, Anthony F. DePalma. Ed. 4. Pp. 240. Price $7.50. Philadelphia, J. P. Lippincott Company.

DIE WIRBELSAULENVERLETZUNGEN UND IHRE AUSKEILUNG. By Prof. Dr. Med. Alfons Lob. Pp. 272, with 149 illustrations. Price $18.55. Stuttgart, Georg Thieme Verlag, Agent for U. S. A.: Grune & Stratton, Inc., New York, N. Y.

LEHRBUCH DER RONTGENOLOGISCHEN DIFFERENTIALDIAGNOSTIK. By von Prof. Dr. W. Teschendorf. Pp. 1,037, with 1,610 illustrations. Price $44.30. Stuttgart, Georg Thieme Verlag, Agent for U. S. A.: Grune & Stratton, Inc., New York, N. Y.

ANGIOPATHIA DIABETICA. By Prof. Dr. M. Burger. Pp. 190, with 81 illustrations. Price $16.40. Stuttgart, Georg Thieme Verlag, Agent for U. S. A.: Grune & Stratton, Inc., New York, N. Y.

HYSTERECTOMY. By Dr. J. C. Burch, and Dr. H. T. Lavely, Duke Hospital, Durham, N. C. Pp. 94. Price $5.50. Springfield, Charles C Thomas, Publisher.

REVIEW OF MEDICAL MICROBIOLOGY. By Dr. E. Jawetz, University of California, San Francisco, Dr. J. L. Melnick, Yale University, New Haven, Conn., and Dr. E. A. Adelberg, University of California, Berkeley. Pp. 360, with 92 illustrations. Price $4.50. Los Altos, Calif., Lange Medical Publications.

OPERATIVE CHOLANGIOGRAPHIE. By Dr. Walter Hess, co-author, Prof. R. Nissen. Pp. 201, with 150 illustrations. Price $10. Stuttgart, Georg Thieme Verlag, Agent for U. S. A.: Grune & Stratton, Inc., New York, N. Y.

SURGERY OF THE ADRENAL GLANDS. By Dr. Wm. Wallace Scott, and Dr. Perry B. Hudson. Pp. 150, with 35 illustrations. Price $3.50. Springfield, Charles C Thomas, Publisher.

LEGG-CALVE-PERTHES SYNDROME. By Dr. Charles Weer Goff, Assistant Clinical Professor of Orthopedics, Yale University. Pp. 332, with 124 illustrations. Price $10.75. Springfield, Charles C Thomas, Publisher.

THE AUXILIARY HEART. By Dr. Wm. Walter Wasson. Pp. 184, with 72 illustrations. Price $10.50. Springfield, Charles C Thomas, Publisher.

BONE, AN INTRODUCTION TO THE PHYSIOLOGY OF SKELETAL TISSUE. By Dr. Franklin C. McLean, and Marshall R. Urial. Pp. 182, with 26 illustrations. Price $6. Chicago, University of Chicago Press.

SURGERY OF THE HEART. By Dr. C. P. Bailey, Hahnemann Medical College, Philadelphia. Pp. 1,062, with 1,452 illustrations. Price $25. Philadelphia, Lea & Febiger.

LIVER, PANCREAS AND BILIARY TRACT. By Dr. J. R. Twiss, and E. Oppenheim, New York University Postgraduate School, New York. Pp. 653, with 133 illustrations. Price $15. Philadelphia, Lea & Febiger.

HAND INJURIES. By Dr. H. M. Nichols, University of Oregon, Portland. Pp. 352, with 180 illustrations. Price $9.50. Chicago, The Year Book Publishers, Inc.

DIE CHIRURGIE DES ELLBAGENGELINKES. By Dr. O. Wustmann. Pp. 332, with 118 illustrations. Berlin, W. de Gruyter & Co.

DIE ASEPTISCHEN CHANDRO-ASTEONETROSEN. By Dr. Med. O. Hauplli. Pp. 233, with 147 illustrations. Berlin, Walter de Gruyter & Co.

PERIPHERAL NERVE INJURIES. By Medical Research Council, Edited by H. J. Seddan. Pp. 451, with 276 illustrations. Bristol, England, John Wright & Sons, Ltd.

PERIPHERAL VASCULAR DISEASES. By Dr. Edgar V. Allen, Dr. Nelson W. Barker, and Dr. Edgar A. Hines, Jr. Ed. 2. Pp. 825, with 316 illustrations. Philadelphia, W. B. Saunders Company.

FRACTURES IN CHILDREN. By Dr. Walter P. Blount. Pp. 279, with 311 illustrations. Price $9.50. Baltimore, Williams and Wilkins Company.

THE ABNORMAL PNEUMOENCEPHOLOGRAM. By Dr. Leo M. Davidoff, and Bernard S. Epstein, Mount Sinai Hospital, New York. Ed. 2. Pp. 518, with 696 illustrations. Price $15. Philadelphia, Lea & Febiger.

DIE GRUNDLAGEN DER TRANSPLANTATION VON FREMDEN KNOCHENGEWEBE. By Dr. Med. Wolfgang Lentz. Pp. 111, with 47b illustrations. Price $4.30. Stuttgart, Georg Thieme Verlag, Agent for U. S. A.: Grune & Stratton, Inc., New York N. Y.

LA PONCTIAN GANGLIONNAIRE. By Dr. Robert Andre, and Dr. Bernard Dreyfus. Pp. 199, with 192 illustrations. Stuttgart, Georg Thieme Verlag, Agent for U. S. A.: Grune & Stratton, Inc., New York, N. Y.

AN ATLAS OF OPERATIONS FOR TRAUMA. By Dr. Otto Russe. Pp. 106, with 48 illustrations. Price $12.50. Wien-Bonn, Wilhelm Maudrich.

AIRBORNE CONTAGION AND AIR HYGIENE. By Dr. Wm. Firch Wells. Pp. 423, with 32 illustrations. New Haven, Harvard University Press.

SHEARER'S MANUAL OF HUMAN DISSECTION. By Dr. Charles E. Tobin, Professor of Anatomy, University of Rochester. Ed. 3. Pp. 287, with 78 illustrations. Price $6. New York, McGraw-Hill Book Company, Inc.

SYNOPSIS OF SURGERY. By Dr. Hey Groves. Ed. 14. Pp. 651, with 190 illustrations. Price $7. Baltimore, Williams & Wilkins Company.

CLINICAL DISORDERS OF HYDRATION AND ACID-BASE EQUILIBRIUM. By Dr. Louis G. Welt, Professor of Medicine, University of North Carolina. Pp. 262. Boston, Little, Brown & Company.

SEGMENTAL ANATOMY OF THE LUNGS. By Dr. Ed. A. Boyden. Pp. 276, with 122 illustrations. Price $15. New York, McGraw-Hill Book Company, Inc.

LEHRBUCH UND ATLAS DER ANATOMIE DES MENSCHEN. By Dr. F. Kopsch. Pp. 736, with 731 illustrations. Price $15.35. Stuttgart, Georg Thieme Verlag, Agent for U. S. A.: Grune & Stratton, Inc., New York, N. Y.

Announcement

The Owen H. Wangensteen Surgical Education Foundation, an organization made up of former residents of Dr. Wangensteen, is honoring the twenty-fifth anniversary of the appointment of Dr. Wangensteen as Professor of Surgery and Chief of the Department of Surgery at the University of Minnesota by presenting a scientific program to be held in the Mayo Memorial Auditorium of the University Hospitals on September 23 and 24, 1955. A public banquet will be held on the evening of September 23 to honor Dr. Wangensteen. The principal speaker will be Mr. John Russell, Executive Director of The John and Mary Markle Foundation. On the succeeding evening there will be a meeting of The Owen H. Wangensteen Surgical Education Foundation.

A Tentative Program of Papers to Be Presented on September 23 and 24, 1955, at the Mayo Auditorium of the University Hospitals, Minneapolis, Minn.

Experimental Surgery

A Parenchymatous Surgical Approach to the Problem of Portal Hypertension:
Davitt A. Felder, St. Paul, Minn.

A Study of the Genesis of Shock Associated With Experimentally Induced Hepatic Necrosis in Dogs:
David State, Cedars of Lebanon Hospital, Los Angeles, Calif.

Continence of the Esophagogastric Sphincter in Experimental Hiatus Hernia on Dogs:
Stanley R. Friesen and Don R. Miller (By Invitation), Kansas City, Kan.

Experiences With Tissue-Specific Antibodies:
John R. Paine, Buffalo, N. Y.

Endocrine Control of Mammary Glands in C_3H Mice:
D. J. Ferguson, Minneapolis, Minn.

The Cancer Problem

The Surgical Management of Cancer of the Tongue:
Arnold J. Kremen, New York, N. Y.

Studies of the Spread and Operative Management of Cancer of the Stomach:
Stuart W. Arhelger, Minneapolis, Minn.

Experience With the Treatment of Primary and Metastatic Tumors of the Liver:
Irving M. Ariel, New York, N. Y.

Cancer of the Pancreas:
Clarence Dennis, Brooklyn, N. Y.

Cordotomy in the Treatment of Metastatic Cancer of the Breast:
Lyle A. French, Minneapolis, Minn.

The Management of Gastric Polyps:
Lyle Hay, Minneapolis, Minn.

Progress in Cancer Detection:
Claude R. Hitchcock and Albert Sullivan, Minneapolis, Minn.

Research Techniques for Investigating the Cigarette Smoking-Lung Cancer Problem:
George E. Moore, Buffalo, N. Y.

Surgical Problems

Meconium Coli: A Problem in Differential Diagnosis and Surgical Management:
H. William Clatworthy, Jr., Columbus, Ohio.

Re-establishment of Abdominal Domain:
Edward E. Mason, Iowa City, Iowa.

Carbohydrate Metabolism in Surgical Patients:
Carl Rice and Jacob Strickler, Minneapolis, Minn.

Mechanisms of Na Metabolism in Surgery:
Bernard Zimmermann, James H. Casey (By Invitation), and Henry Bloch (By Invitation), Minneapolis, Minn.

Hemolysis Occurring During Transurethral Resection of the Prostate:
C. D. Creevy, Minneapolis, Minn.

The Intradiaphragmatic Distribution of the Phrenic Nerve With Special Attention to the Placement of Diaphragmatic Incisions: An Experimental and Clinical Study:
K. Alvin Merendino, Seattle, Wash.

An operative clinic on cardiac surgery will be presented on September 22, 1955, (Thursday) for those who may be interested.

Participants will include Drs. Lewis, Varco, Lillehei, Campbell, and others.

Coronary Heart Disease: A Surgical Evaluation:
Ivan D. Baronofsky, St. Paul, Minn.